

ISSN 0006 8241 = Bothalia

Bothalia

'N TYDSKRIF VIR PLANTKUNDIGE NAVORSING
A JOURNAL OF BOTANICAL RESEARCH

Vol. 20,1

May/Mei 1990

PUBLICATIONS OF THE NATIONAL BOTANICAL INSTITUTE, PRETORIA PUBLIKASIES VAN DIE NASIONALE BOTANIESE INSTITUUT, PRETORIA

Obtainable from the National Botanical Institute, Private Bag X101, Pretoria 0001, Republic of South Africa. A current price list of all available publications will be issued on request.

Verkrygbaar van die Nasionale Botaniese Instituut, Privaatsak X101, Pretoria 0001, Republiek van Suid-Afrika. 'n Geldige lys van alle beskikbare publikasies kan aangevra word.

BOTHALIA

Bothalia is named in honour of General Louis Botha, first Premier and Minister of Agriculture of the Union of South Africa. This house journal of the National Botanical Institute, Pretoria, is devoted to the furtherance of botanical science. The main fields covered are taxonomy, ecology, anatomy and cytology. Two parts of the journal and an index to contents, authors and subjects are published annually.

Bothalia is vernoem ter ere van Generaal Louis Botha, eerste Eerste Minister en Minister van Landbou van die Unie van Suid-Afrika. Hierdie lyfblad van die Nasionale Botaniese Instituut, Pretoria, is gewy aan die bevordering van die wetenskap van plantkunde. Die hoofgebiede wat gedek word, is taksonomie, ekologie, anatomie en sitologie. Twee dele van die tydskrif en 'n indeks van die inhoud, outeurs en onderwerpe verskyn jaarliks.

MEMOIRS OF THE BOTANICAL SURVEY OF SOUTH AFRICA MEMOIRS VAN DIE BOTANIESE OPNAME VAN SUID-AFRIKA

The memoirs are individual treatises usually of an ecological nature, but sometimes dealing with taxonomy or economic botany.

'n Reeks van losstaande omvattende verhandelings oor vernaamlik ekologiese, maar soms ook taksonomiese of plantekonomiese onderwerpe.

THE FLOWERING PLANTS OF AFRICA / DIE BLOMPLANTE VAN AFRIKA

This serial presents colour plates of African plants with accompanying text. The plates are prepared mainly by the artists at the National Botanical Institute. Many well known botanical artists have contributed to the series, such as Cythna Letty (over 700 plates), Kathleen Lansdell, Stella Gower, Betty Connell, Peter Bally and Fay Anderson. The Editor is pleased to receive living plants of general interest or of economic value for illustration.

From Vol. 50, one part of twenty plates is published annually. A volume consists of two parts. The publication is available in English and Afrikaans.

Hierdie reeks bied kleurplate van Afrikaanse plante met bygaande teks. Die skilderye word meestal deur die kunstenaars van die Nasionale Botaniese Instituut voorberei. Talle bekende botaniese kunstenaars het tot die reeks bygedra, soos Cythna Letty (meer as 700 plate), Kathleen Lansdell, Stella Gower, Betty Connell, Peter Bally en Fay Anderson. Die Redakteur verwelkom lewende plante van algemene belang of ekonomiese waarde vir afbeelding.

Vanaf Vol. 50 word een deel, bestaande uit twintig plate, jaarliks gepubliseer. 'n Volume bestaan uit twee dele. Die publikasie is beskikbaar in Afrikaans en Engels.

FLORA OF SOUTHERN AFRICA / FLORA VAN SUIDELIKE AFRIKA

A taxonomic treatise on the flora of the Republic of South Africa, Ciskei, Transkei, Lesotho, Swaziland, Bophuthatswana, South West Africa/Namibia, Botswana and Venda. The FSA contains descriptions of families, genera, species, infraspecific taxa, keys to genera and species, synonymy, literature and limited specimen citations, as well as taxonomic and ecological notes. Also available in the FSA series are the following:

'n Taksonomiese verhandeling oor die flora van die Republiek van Suid-Afrika, Ciskei, Transkei, Lesotho, Swaziland, Bophuthatswana, SWA/Namibië, Botswana en Venda. Die FSA bevat beskrywings van families, genusse, spesies, infraspesifieke taksons, sleutels tot genusse en spesies, sinonimie, literatuur, verwysings na enkele eksemplare, asook beknopte taksonomiese en ekologiese aantekeninge. Ook beskikbaar in die FSA-reeks is die volgende:

The genera of southern African flowering plants, by/deur R.A. Dyer, Vol. 1 Dicotyledons (1975); Vol. 2 Monocotyledons (1976).

Keys to families and index to the genera of southern African flowering plants, by/deur R.A. Dyer (1977).

Plant exploration of southern Africa by Mary Gunn & L.E. Codd. Obtainable from/Beskikbaar van: A.A. Balkema Marketing, Box/Posbus 317, Claremont 7735, RSA.

PALAEOFLORA OF SOUTHERN AFRICA / PALAEOFLORA VAN SUIDELIKE AFRIKA

A palaeoflora on a pattern comparable to that of the Flora of southern Africa. Much of the information is presented in the form of tables and photographic plates depicting fossil populations. Now available:

'n Palaeoflora met 'n uitleg vergelykbaar met dié van die Flora van suidelike Afrika. Baie van die inligting word aangebied in die vorm van tabelle en fotografiese plate waarop fossiele populasies afgebeeld word. Reeds beskikbaar:

Molteno Formation (Triassic) Vol. 1. Introduction. *Dicroidium*, by/deur J.M. & H.M. Anderson.

Molteno Formation (Triassic) Vol. 2. Gymnosperms (excluding *Dicroidium*), by/deur J.M. & H.M. Anderson.

Prodromus of South African Megaflores. Devonian to Lower Cretaceous, by/deur J.M. & H.M. Anderson.

Obtainable from/Beskikbaar van: A.A. Balkema Marketing, Box/Posbus 317, Claremont 7735, RSA.

BOTHALIA

'N TYDSKRIF VIR PLANTKUNDIGE NAVORSING
A JOURNAL OF BOTANICAL RESEARCH

Volume 20,1

Editor/Redakteur: O.A. Leistner
Assisted by B.A. Momberg

Editorial Board/Redaksieraad

D.F. Cutler	Royal Botanic Gardens, Kew, UK
B. de Winter	Botanical Research Institute, Pretoria, RSA
P.H. Raven	Missouri Botanical Garden, St Louis, USA
J.P. Rourke	National Botanic Gardens, Kirstenbosch, RSA
M.J. Werger	University of Utrecht, Utrecht, Netherlands

Editorial Committee/Redaksiekomitee

B. de Winter	B.A. Momberg
D.J.B. Killick	M.C. Rutherford
O.A. Leistner	J.C. Scheepers

ISSN 0006 8241

Issued by the National Botanic Gardens/Botanical Research Institute, Private Bag X101, Pretoria 0001,
South Africa

Uitgegee deur die Nasionale Botaniese Tuine/Navorsingsinstituut vir Plantkunde, Privaatsak X101
Pretoria 0001, Suid-Afrika

1990

CONTENTS — INHOUD

Volume 20,1

1. Studies in the genus <i>Lotononis</i> (Crotalariaeae, Fabaceae). 9. Four new species of the <i>L. pentaphylla</i> group, section <i>Lipozygis</i> . B-E. VAN WYK	1
2. Studies in the genus <i>Lotononis</i> (Crotalariaeae, Fabaceae). 12. Four new species of the <i>L. falcata</i> group, section <i>Leptis</i> . B-E. VAN WYK	9
3. Studies in the genus <i>Lotononis</i> (Crotalariaeae, Fabaceae). 13. Two new species and notes on the occurrence of cleistogamy in the section <i>Leptis</i> . B-E. VAN WYK	17
4. Studies in the genus <i>Riccia</i> (Marchantiales) from southern Africa. 15. <i>R. hirsuta</i> and <i>R. tomentosa</i> , sp. nov., two distinct species previously treated as one. O.H. VOLK and S.M. PEROLD	23
5. Studies in the genus <i>Riccia</i> (Marchantiales) from southern Africa. 16. <i>R. albomarginata</i> and <i>R. simii</i> , sp. nov. S.M. PEROLD	31
6. New species of <i>Erica</i> (Ericaceae) from the Cape Province. E.G.H. OLIVER	41
7. Studies in the southern African species of <i>Justicia</i> and <i>Siphonoglossa</i> (Acanthaceae): seeds. K.L. IMMELMAN	49
8. Studies in the southern African species of <i>Justicia</i> and <i>Siphonoglossa</i> (Acanthaceae): indumentum. K.L. IMMELMAN	61
9. Notes on African plants: Asclepiadaceae. Corona lobe variation and the generic position of <i>Asclepias macra</i> . A. NICHOLAS and D.J. GOYDER	87
Asteraceae. A new species of <i>Pterothrix</i> (Gnaphalieae) from the northern Cape. F. BRUSSE ...	67
Fabaceae. Studies in the genus <i>Lotononis</i> (Crotalariaeae. 10. <i>L. esterhuyseniana</i> , a new species from the south-western Cape. B-E. VAN WYK	70
Fabaceae. Studies in the genus <i>Lotononis</i> (Crotalariaeae). 11. A new species of the section <i>Leobordea</i> from north-western Namibia. B-E. VAN WYK	73
Fabaceae. Studies in the genus <i>Lotononis</i> (Crotalariaeae). 14. Three new species of the sections <i>Telina</i> and <i>Polylobium</i> . B-E. VAN WYK	75
Liliaceae/Asphodelaceae. The correct author citations of <i>Aloe bowiea</i> and <i>A. myriacantha</i> (Alooideae). G.F. SMITH	80
Poaceae. Two new species of <i>Stipagrostis</i> (Aristideae) from the dune-Namib Desert, Namibia. B. DE WINTER	82
10. Vegetative morphology and interfire survival strategies in the Cape Fynbos grasses. H.P. LINDER and R.P. ELLIS	91
11. The ecology of the False Bay estuarine environments, Cape, South Africa. 1. The coastal vegetation. M. O'CALLAGHAN	105
12. The ecology of the False Bay estuarine environments, Cape, South Africa. 2. Changes during the last fifty years. M. O'CALLAGHAN	113
13. Miscellaneous note: Notes on the distribution and habitat of <i>Aloe bowiea</i> (Liliaceae/Asphodelaceae: Alooideae)—an endangered and little known species from the eastern Cape. G.F. SMITH and A.E. VAN WYK	123
14. Obituary: Mary Davidson Gunn (1899–1989). D.M.C. FOURIE	127
15. Book reviews	131
16. Guide for authors to <i>Bothalia</i>	133



Digitized by the Internet Archive
in 2016

<https://archive.org/details/bothaliavolume2020unse>

Studies in the genus *Lotononis* (Crotalarieae, Fabaceae). 9. Four new species of the *L. pentaphylla* group, section *Lipozygis*

B-E. VAN WYK*

Keywords: Fabaceae, *Lotononis* section *Lipozygis*, sectional limits, new species

ABSTRACT

L. pentaphylla (E. Mey.) Benth. and related species were previously shown to be very different from the rest of the section *Lipozygis* (E. Mey.) Benth. of *Lotononis* (DC.) Eckl. & Zeyh. These species are all annuals and can easily be distinguished by their capitate inflorescences, sessile flowers and indehiscent, wind-dispersed pods. Four new species of this group are described, namely *L. oligocephala* B-E. van Wyk, *L. globulosa* B-E. van Wyk, *L. laticeps* B-E. van Wyk and *L. longicephala* B-E. van Wyk.

UITTREKSEL

Daar is voorheen aangetoon dat *L. pentaphylla* (E. Mey.) Benth. en verwante spesies baie verskillend is van die res van die seksie *Lipozygis* (E. Mey.) Benth. van *Lotononis* (DC.) Eckl. & Zeyh. Hierdie spesies is almal jaarplante en kan maklik onderskei word aan hul hofievormige bloeiwyses, sittende blomme en nie-oopspringende, windverspreide peule. Vier nuwe spesies van hierdie groep word beskryf, naamlik *L. oligocephala* B-E. van Wyk, *L. globulosa* B-E. van Wyk, *L. laticeps* B-E. van Wyk en *L. longicephala* B-E. van Wyk.

INTRODUCTION

Lotononis pentaphylla (E. Mey.) Benth., *L. polycephala* (E. Mey.) Benth., *L. anthylloides* Harv., *L. bolusii* Dümmer and *L. rosea* Dümmer differ from all other annual species of *Lotononis* (DC.) Eckl. & Zeyh. in their densely capitate inflorescences, sessile flowers and indehiscent, wind-dispersed pods (Van Wyk 1989). These five species were previously included by Bentham (1843), Harvey (1862) and Dümmer (1913) in the section *Lipozygis* (E. Mey.) Benth., but their annual habit and unusual morphology have apparently been overlooked. Four new species that clearly belong to this group are described below.

Wind-dispersal is not uncommon in the tribe Crotalarieae but it is usually accomplished by winged pods, as in the genus *Wiborgia* Thunb. Personal observations have shown that wind-dispersal also occurs in *Lotononis benthamiana* Dümmer and in *Lebeckia melilotoides* Dahlgren. In these two species, the highly persistent corolla acts as a wing to facilitate dispersal. *L. pentaphylla* and its allies however, show an unusual and interesting mode of seed dispersal. The tiny pods are few-seeded, totally indehiscent and are completely enclosed by a densely hirsute, much-inflated calyx. When the seeds have matured, the calyx with its enclosed pod is shed from the peduncle. At this stage, the petals are crumpled up and withered, but the total absence of a pedicel and the hairy, inflated calyx result in a very effective dispersal by wind. Only a slight wind is necessary to move the pod (diaspore) over long distances by a rolling rather than floating action. Morphological features associated with this dispersal mechanism are unique within the genus *Lotononis* and therefore valuable as diagnostic characters. The total

absence of a pedicel is the most obvious one, and perhaps also the most useful.

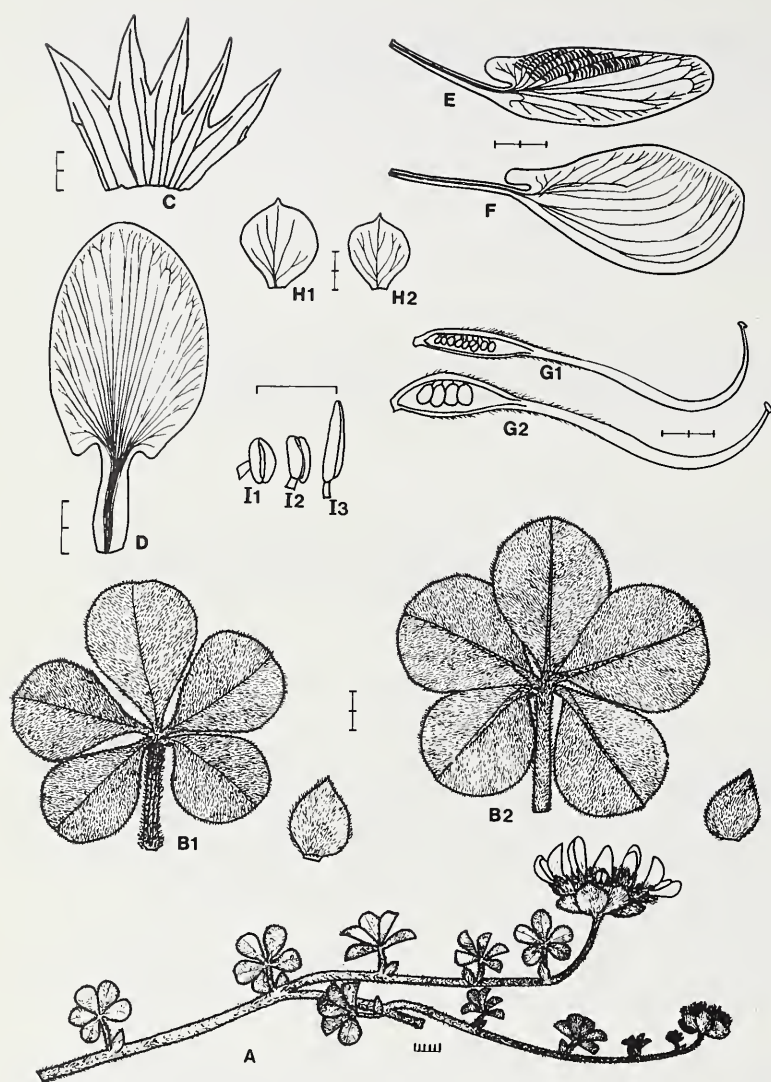
1. *Lotononis oligocephala* B-E. van Wyk, sp. nov., *L. polycephalae* (E. Mey.) Benth. valde affinis, sed foliis minoribus 5-foliolatis (in *L. polycephala* 3-foliolatis), inflorescentiis floribus bracteisque minoribus, lobis calycis brevioribus latioribusque, atque corolla omnino glabra (in *L. polycephala* dense pubescente) differt.

TYPE. — Cape Province, 2918 (Gamoep): Areb, \pm 27 miles [43,2 km] NE of Springbok, 25.07.1972, Van der Westhuizen 276 (PRE, holo.; K, MO, iso.).

Prostrate annual up to 0,8 m wide. Branches sparsely leafy, densely silky. Leaves invariably 5-foliolate, (6–)10–18(–24) mm long; petiole \pm as long as the terminal leaflet or longer; leaflets relatively small, broadly obovate, (3–)5–8(–10) mm long, (2–)3–5(–7) mm wide, base cuneate, apex truncate to emarginate, densely silky on both surfaces. Stipules single at each node, lanceolate to broadly ovate, 3–4 mm long, 2–3 mm wide, densely silky on both surfaces. Inflorescences in terminal heads, the heads somewhat flattened, 4–8-flowered; peduncle variable in length, 5–50 mm long; bracts large, broadly obovate, $\pm 4 \times \pm 4$ mm; bracteoles absent. Flowers relatively small, 12–14 mm long, yellow; pedicel absent. Calyx subequally lobed but with the lower lobe slightly narrower than the upper four lobes, the sinuses of equal depth; lobes broadly triangular, acute. Standard oblong, as long as the keel; claw 4–5 mm long; lamina ± 8 mm long, 5–6 mm wide, without lobes or callosities, glabrous but with a few hairs dorsally along the middle. Wing petals oblong, \pm as long as the keel, glabrous; auricle small, ± 1 mm long; apex obtuse; sculpturing in 4–5 rows of intercostal lunae, fading into transcostal lamellae towards the auricle. Keel petals obovate-oblong, only slightly auriculate; claw 5 mm long; lamina 9 mm long, 5 mm wide, glabrous; apex rounded. Androecium

* Department of Botany, Rand Afrikaans University, P. O. Box 524, Johannesburg 2000.

MS. received: 1989.04.12.

FIGURE 1.—*Lotononis oligocephala*.

A, flowering twig; B1 & B2, leaves and stipules: B1, adaxial view, B2, abaxial view; C, calyx opened out with the upper lobes to the left (vestiture not shown); D, standard petal; E, wing petal; F, keel petal; G1 & G2, pistils: G1, from young flower, G2 from older flower; H1 & H2, bracts; I1, I2 & I3, anthers: I1, dorsifixed anther, I2, carinal anther, I3, long basifixed anther. All from *Van der Westhuizen 276*. Scales in mm.

long and narrow; anthers dimorphic; basifixed anthers oblong, slightly longer than the small ovoid dorsifixed anthers; carinal anther similar to dorsifixed anthers. *Gynoecium* sessile; pistil very small, ovoid-oblong, pubescent, with 5–12 ovules; style long and slender. *Pods* and *seeds* unknown (Figure 1).

L. oligocephala is closely related to *L. polycephala* (E. Mey.) Benth. but can easily be distinguished by the much smaller and 5-foliolate leaves (3-foliolate in *L. polycephala*), the smaller inflorescences and flowers, the smaller bracts, the shorter and wider calyx lobes, and the corolla, which is totally glabrous (densely pubescent in *L. polycephala*). This species is known only from the type collection, which is from northern Namaqualand (Figure 2).

CAPE.—2918 (Gamoe): Areb, \pm 27 miles [43,2 km] NE of Springbok (—AC), *Van der Westhuizen 276* (PRE, holo.; K, MO, iso.).

2. *L. globulosa* B-E. van Wyk, sp. nov., *L. pentaphyllae* (E. Mey.) Benth. et *L. bolusii* Dümmer similis, sed bracteis maximis late ovatis, floribus paulo maioribus,

vexillo suborbiculari (non oblongo) et foliis semper 3-foliolatis (folia quidem nonnulla 5-foliolata in *L. pentaphylla* et *L. bolusii*). Praesertim similis *L. laticipae* B-E. van Wyk, sed ab illo specie inflorescentiis globosis (non discoideis), bracteis maioribus, vestitura densius hirsuta, vexillo longiore, lobis calycis latioribus, atque lobis calycis duobus superioribus latioribus quam inferioribus (superioribus inferioribus aequantibus in *L. laticipae* differt).

TYPE.—Cape Province, 3320 (Montagu): 29,5 km from Touws River to Laingsburg, near Tweedside, 13.10.1986, B-E. van Wyk 2210 (PRE, holo.).

Prostrate annual up to 0,4 m wide. *Branches* sparsely leafy, densely to sparsely hirsute. *Leaves* invariably 3-foliolate, (5–)8–16(–32) mm long; petiole as long or usually longer than the terminal leaflet; leaflets comparatively small, oblanceolate to obovate, (3–)5–10(–14) \times (1–)3–4(–6) mm, base cuneate, apex rounded or rarely emarginate, abaxial surface sparsely hirsute, adaxial

surface glabrous. *Stipules* single at each node, lanceolate to oblong, $3-6 \times \pm 1$ mm. *Inflorescences* in terminal heads, the heads globose, 8–20-flowered; peduncle variable in length, usually short, 5–25 mm long; bracts large, very broadly ovate, $(4-7)-10 \times (4-7)-10$ mm; bracteoles absent. *Flowers* relatively small, 9–10 mm long, yellow; pedicel absent. *Calyx* subequally lobed but with the two upper lobes slightly wider than the lower lobes, the sinuses of \pm equal depth; lobes narrowly triangular, acute. *Standard* suborbicular, as long as the keel or slightly shorter; claw ± 4 mm long; lamina $5-6 \times 5-8$ mm, without lobes or callosities, pubescent over most of the abaxial surface. *Wing petals* oblong, \pm as long as the keel, pubescent along the apex; auricle small, $\pm 0,5$ mm long; apex obtuse; sculpturing in 4–5 rows of intercostal lunae, fading into transcostal lamellae towards the auricle. *Keel petals* obovate, only slightly auriculate; claw ± 4 mm long; lamina $4-6 \times 3-4$ mm, pubescent over most of the surface; apex rounded. *Androecium* long and narrow; anthers dimorphic; basifixed anthers oblong, slightly longer than the small ovoid dorsifixed anthers; carinal anther similar to dorsifixed anthers. *Gynoecium* sessile; pistil very small, ovoid-oblong, pubescent, with 5–9 ovules; style long and slender. *Pods* very small, ovoid, $\pm 4 \times 2,5$ mm, much inflated laterally, totally indehiscent, enclosed by the persistent and much-inflated calyx; upper suture minutely verrucose, 2–3-seeded. *Seeds* suborbicular, $\pm 1,5$ mm in diameter, testa minutely but densely tuberculate (Figure 3).

L. globulosa is similar to *L. pentaphylla* (E. Mey.) Benth. and *L. bolusii* Dümmer but differs in the very large, broadly ovate bracts, the slightly larger flowers, the suborbicular (not oblong) standard petal and in the consistently 3-foliolate leaves (always at least some leaves 5-foliolate in *L. pentaphylla* and *L. bolusii*). It is particularly similar to *L. laticeps* B-E. van Wyk, but differs from this species in the globose (not discoid) inflorescences, the larger bracts, the more hirsute vestiture, the longer standard petal, the wider calyx lobes and the two upper calyx lobes, which are wider than the lower lobes (upper lobes as wide as the lower lobes in *L. laticeps*). These differences are clearly shown in Figures 3 & 4. This species is known from a limited area in the southwestern Cape (Figure 2), where it is perhaps more common than the very poor herbarium record would suggest.

CAPE.—3319 (Worcester): Ceres Division, Gydouw (—AB), *Leipoldt* 3123 (BOL, K); Ceres District, Laken Vlei (—BC), *Compton* 12074 (NBG), *Leyns* 1053 (BOL, SAM). 3320 (Montagu): 29,5 km from Touws River to Laingsburg, near Tweedside (—AD), B-E. van Wyk 2210 (PRE, holo.), 2211 (JRAU).

3. *L. laticeps* B-E. van Wyk, sp. nov., *L. globulosae* B-E. van Wyk valde affinis, sed capitulis discoideis (non globosis), bracteis minoribus, vestitura sparsiori breviori, vexillo breve carina valde breviori (vexillum carinam in *L. globulosa* speciebusque affinis aequans) differt. A *L. globulosa* calyce minori sub-pariter lobato (superioribus inferioribus haud latioribus), lobis angustioribus etiam differt. A *L. pentaphylla*, *L. bolusii*, *L. roseae* etiam folios semper 3-foliolatis, bracteis valde maioribus late ovatis (non linearibus nec lanceolatis) atque vexillo suborbiculari (non oblongo) etiam differt.

TYPE.—Cape Province, 3219 (Wuppertal): Ceres District, Stompiesvlei, Swartruggens (sandy stony plateau, 3500 ft.), 19.II.1961, *Esterhuysen* 29334 (BOL, holo.; C, K, M, MO, S, iso.).

Prostrate annual up to 0,3 m wide. *Branches* sparsely leafy, minutely hirsute. *Leaves* invariably 3-foliolate, $(6-12)-15(-17)$ mm long; petiole \pm as long as the terminal leaflet or slightly longer; leaflets relatively small, oblanceolate to obovate, $(3-5)-8(-10) \times (1,5-3)-4(-5)$ mm, base cuneate, apex rounded to truncate, sparsely hirsute on both surfaces. *Stipules* single at each node, lanceolate to oblong, $3-5$ mm $\times \pm 1$ mm. *Inflorescences* in terminal heads, the heads discoid (wider than long), 8–20-flowered; peduncle variable in length, 3–28 mm long; bracts large, broadly ovate, $4-5 \times 4-5$ mm; bracteoles absent. *Flowers* relatively small, 9–10 mm long, yellow; sessile. *Calyx* subequally lobed, the sinuses of \pm equal depth; lobes narrowly linear, acute. *Standard* suborbicular, much shorter than the keel; claw 1–2 mm long; lamina $\pm 3 \times \pm 4$ mm, without lobes or callosities, pubescent over most of the abaxial surface. *Wing petals* oblong, shorter than the keel, pubescent along the apex; auricle small, $\pm 0,5$ mm long; apex obtuse; sculpturing in 4–5 rows of intercostal lunae, fading into transcostal lamellae towards the auricle. *Keel petals* oblong, only slightly auriculate; claw $\pm 2,5$ mm long; lamina $\pm 6 \times \pm 3$ mm, pubescent over most of the surface; apex rounded. *Androecium* long and narrow; anthers dimorphic; basifixed anthers oblong, slightly longer than the small ovoid dorsifixed anthers; carinal anther similar to dorsifixed anthers. *Gynoecium* sessile; pistil very small, ovoid-oblong, pubescent, with 2–4 ovules; style long and slender. *Pods* and *seeds* unknown (Figure 4).

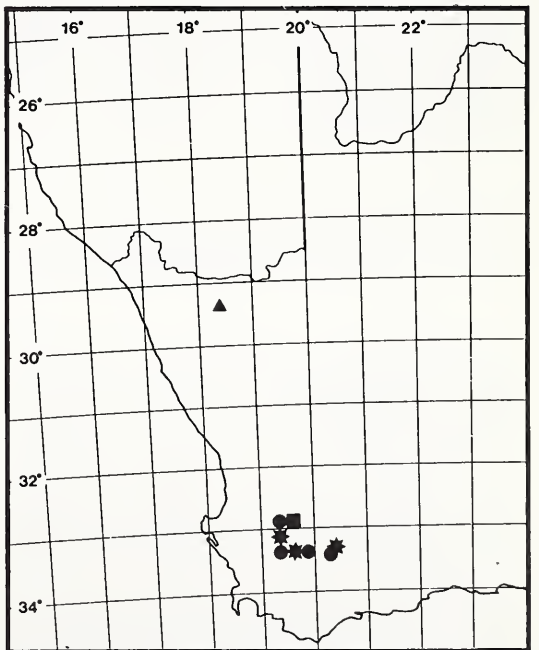


FIGURE 2.—The known geographical distribution of *Lotononis oligocephala*, ▲; *L. globulosa*, ★; *L. laticeps*, ■; and *L. longicephala*, ●.

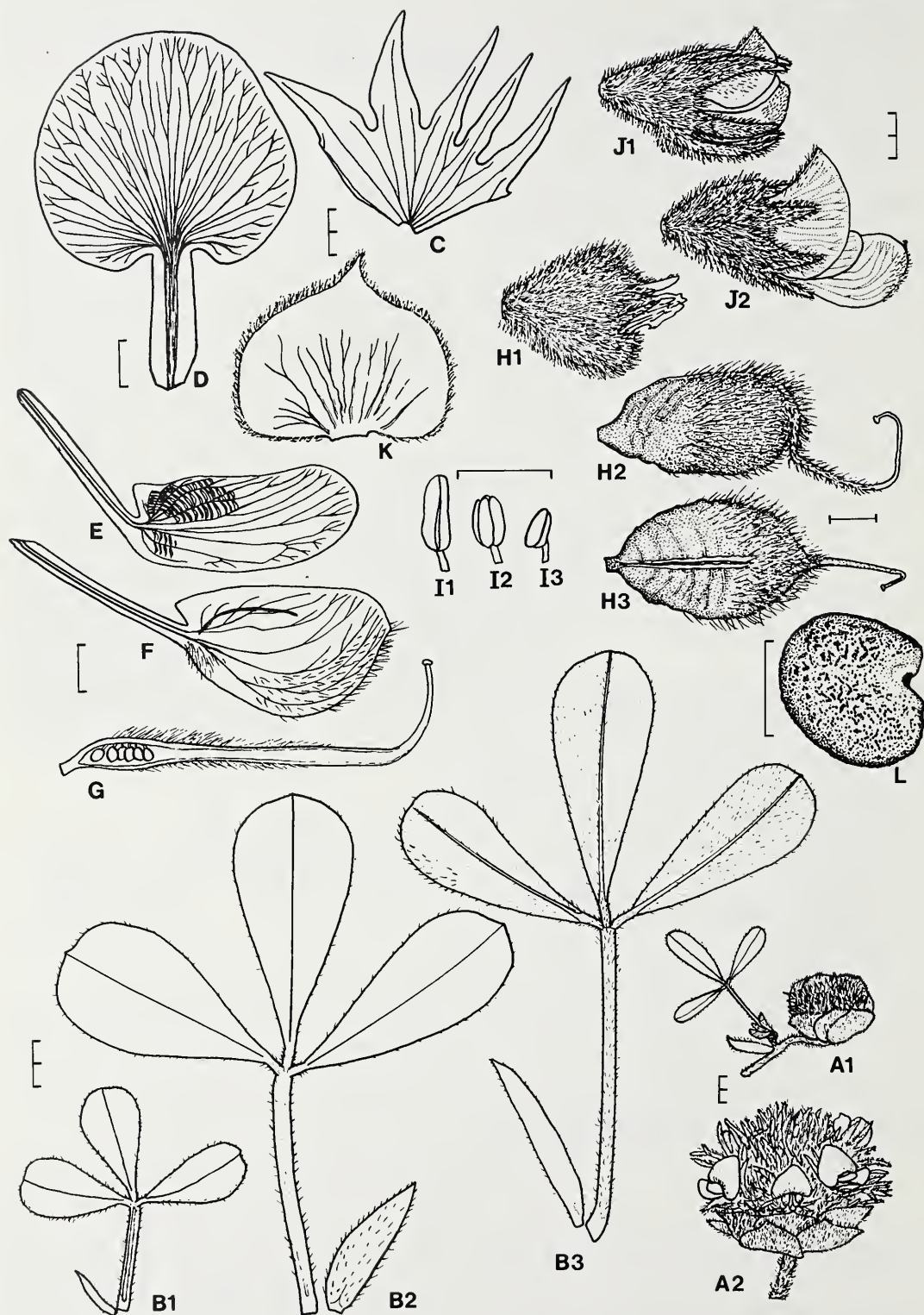


FIGURE 3.—*Lotononis globulosa*. A1 & A2, inflorescences: A1, young inflorescence, A2, mature inflorescence showing the globose shape and large bracts; B1, B2 & B3, leaves and stipules: B1 & B2, adaxial view, B3, abaxial view; C, calyx opened out with the upper lobes to the left (vestiture not shown); D, standard petal; E, wing petal; F, keel petal; G, pistil; H1, mature fruit (dispersal unit or diaspore), showing the persistent inflated calyx which totally encloses the pod; H2 & H3, pods with the calyx removed: H2, lateral view, H3, top view; I1, I2 & I3, anthers: I1, long basifixed anther, I2, carinal anther, I3, dorsifixed anther; J1 & J2, flowers in lateral view; K, bract; L, seed in lateral view. All from Van Wyk 2210 except J1 from Van Wyk 2211, J2 from Leipoldt 3123. Scales in mm.

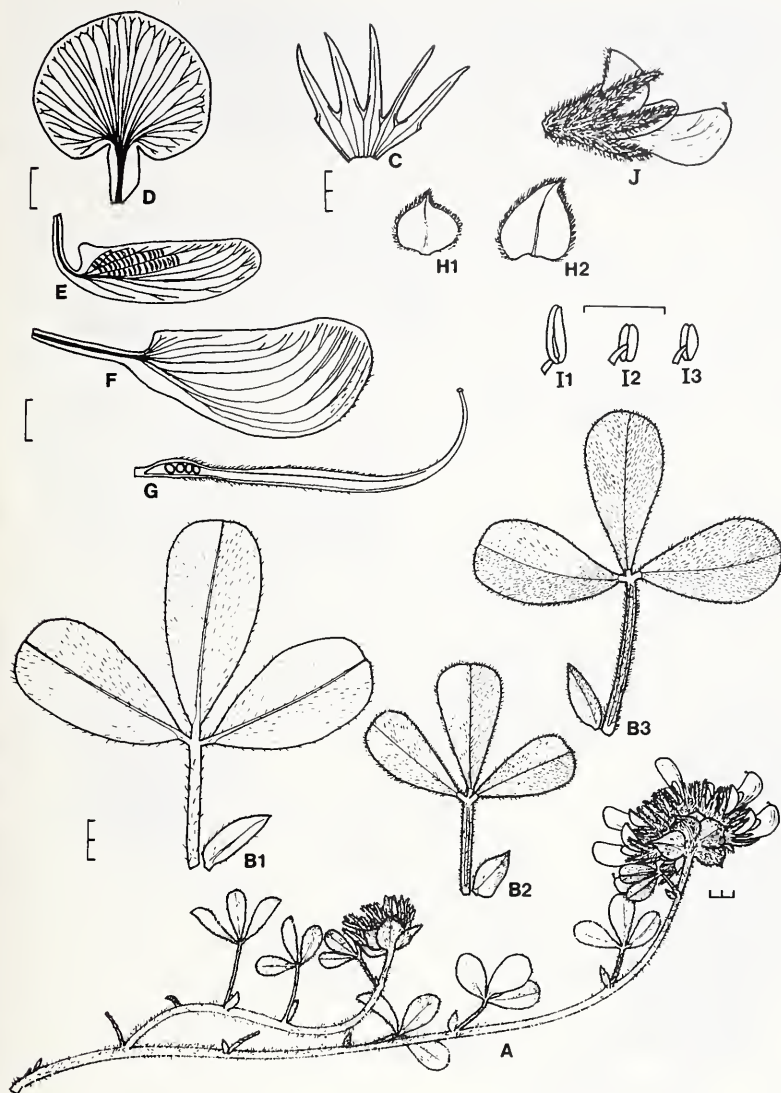


FIGURE 4. —*Lotononis laticeps*. A, flowering twig; B1, B2 & B3, leaves and stipules: B1, abaxial view, B2 & B3, adaxial view; C, calyx opened out with the upper lobes to the left (vestiture not shown); D, standard petal; E, wing petal; F, keel petal; G, pistil; H1 & H2, bracts; I1, I2 & I3, anthers: I1, basifixed anther, I2, carinal anther, I3, dorsifixed anther; J, flower in lateral view showing the short standard petal. All from Esterhuysen 29334. Scales in mm.

This poorly known species has so far been recorded only from a single locality in the Ceres District (Figure 2). It is very closely related to *L. globulosa*, but can easily be distinguished by the short standard petal. Other diagnostic characters (see Figures 3 & 4) are given under *L. globulosa*.

CAPE.—3219 (Wuppertal): Ceres District, Stompiesvlei, Swartuggens (—DC), Esterhuysen 29334 (BOL, holo.; C, K, M, MO, S, iso.).

4. *L. longicephala* B-E. van Wyk, sp. nov., distincta sine affinitatibus manifestis. Similis est *L. pentaphyllae* (E. Mey.) Benth. et *L. bolusii* Dümmer, sed ab illis speciebusque omnibus affinis foliis semper 3-foliolatis, capitulis valde minoribus oblongis (non globosis nec discoideis), floribus leguminibusque valde minoribus differt. A *L. globulosa* B-E. van Wyk et *L. laticeps* B-E. van Wyk etiam bracteolis linearibus inconspicuis (non magnis ovatis) differt.

TYPE.—Cape Province, 3319 (Worcester): flats east of Prince Alfred's Hamlet, 10.10.1974, Oliver 5063 (PRE, holo.; K, MO, STE, iso.).

Prostrate annual, 0,5–0,8 m wide. Branches sparsely leafy, sparsely pubescent. Leaves invariably 3-foliolate, (5–)10–14(–22) mm long; petiole \pm as long as the terminal leaflet; leaflets relatively small, oblanceolate to obovate, (3–)5–9(–12) \times (1,5–)3–4(–6) mm, base cuneate, apex truncate to emarginate, abaxial surface sparsely pubescent, adaxial surface glabrous. Stipules single at each node, lanceolate, 2–6 \times \pm 1 mm. Inflorescences in terminal or subterminal heads, the heads globose when young, oblong when fully developed, (4–)12–52-flowered; peduncle variable in length, 5–24 mm long; bracts small, linear or narrowly lanceolate, 2–3 mm long, up to 0,5 mm wide; bracteoles absent. Flowers very small, \pm 6 mm long, yellow; pedicel absent. Calyx subequally lobed, the sinuses of \pm equal depth; lobes

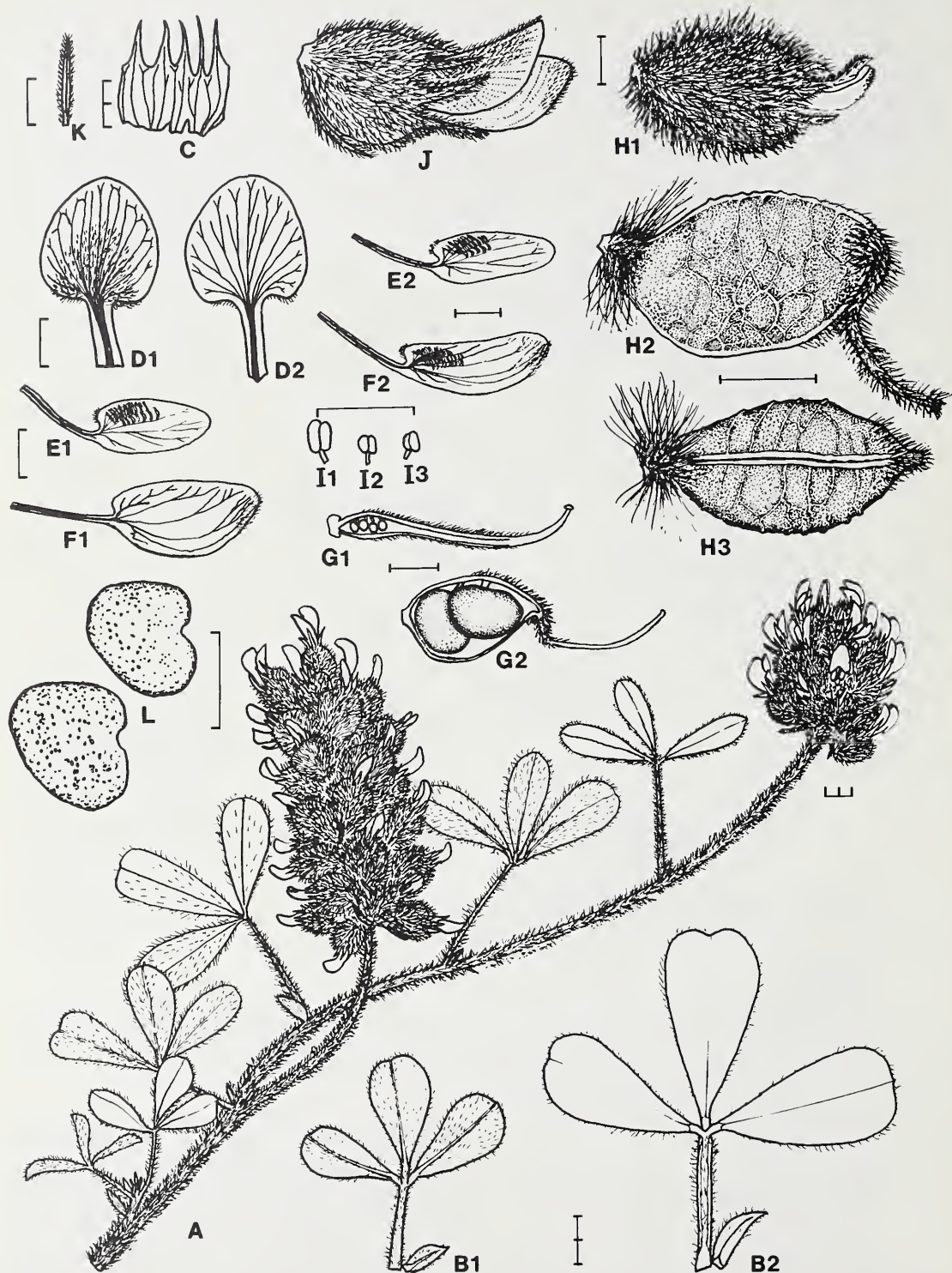


FIGURE 5.—*Lotononis longicephala*. A, flowering twig, showing the elongated (spicate) inflorescences; B1 & B2, leaves and stipules: B1, abaxial view, B2, adaxial view; C, calyx opened out with the upper lobes to the left (vestiture not shown); D1 & D2, standard petals: D1, abaxial view, D2, adaxial view; E1 & E2, wing petals; F1 & F2, keel petals (note sculpturing on F2); G1, pistil; G2, young pod; H1, mature fruit (dispersal unit or diaspore), showing the persistent inflated calyx which totally encloses the pod; H2 & H3, pods with the calyx removed: H2, lateral view, H3, top view; I1, I2 & I3, anthers: I1, long basifixed anther, I2, carinal anther, I3, dorsifixed anther; J, flower in lateral view; K, bract; L, seeds in lateral view, showing the sparsely tuberculate surface. All from *Van Wyk 2200* except C, D1, E2, F2, G2 & K from *Esterhuysen 29299*. Scales in mm.

narrowly triangular, acute. *Standard* suborbicular, as long as the keel; claw $\pm 1,5$ mm long; lamina $\pm 2,5 \times \pm 4$ mm, without lobes or callosities, abaxially pubescent over most of the basal part. *Wing petals* oblong, almost as long as the keel, glabrous except for a few hairs on the auricle and near the attachment of the claw; auricle small; apex obtuse; sculpturing in 4–5 rows of intercostal lunae, fading into transcostal lamellae towards the auricle. *Keel petals* oblong, only slightly auriculate; claw ± 2 mm long; lamina $\pm 3 \times \pm 1,5$ mm, pubescent at least towards the apex; apex rounded. *Androecium* long and narrow; anthers dimorphic; basifixed anthers broadly oblong, much larger than the small ovoid dorsifixed anthers; carinal anther similar to dorsifixed anthers. *Gynoecium* sessile; pistil very small, ovoid-oblong, pubescent, with 3–4 ovules; style long and slender. *Pods* very small, ovoid, $\pm 2,5 \times \pm 1,5$ mm, much inflated laterally, totally indehiscent, enclosed by the persistent and much-inflated calyx; upper suture minutely verrucose, 2–3-seeded. *Seeds* suborbicular, $\pm 1,2$ mm in diameter, testa sparsely tuberculate (Figure 5).

L. longicephala is a distinct species with no obvious affinities. It is similar to *L. pentaphylla* and *L. bolusii*, but differs from these and all related species in the consistently 3-foliolate leaves, the much smaller and oblong (not globose or discoid) heads, the much smaller flowers and the much smaller pods. It differs from *L. globulosa* and *L. laticeps* also in the inconspicuous, linear bracts (Figure 5). *L. longicephala* is known only from the vicinity of Touws River in the south-western Cape (Figure 2).

CAPE.—3219 (Wuppertal): Ceres District, E foot of Schurweberg (next to Bokkeveld Tafelberg) (—CD), *Esterhuysen 20631* (BOL); near the base of Schurweberg Peak (—CD), *Esterhuysen 29299* (BOL, C, K, S). 3319 (Worcester): flats east of Prince Alfred's Hamlet (—AD), *Oliver 5063* (PRE, holo.; K, MO, STE, iso.); Verkeerdelei, 64,5 km from Ceres to Touws River (—BD), *B-E. van Wyk 2241* (BOL, C, GRA, JRAU, K, MO, NBG, PRE, SAAS, STE). 3320 (Montagu): 29,5 km from Touws River to Laingsburg, near Tweedside (—AD), *B-E. van Wyk 2200* (JRAU), 2202 (BOL), 2203 (GRA), 2204 (K), 2205 (MO), 2206 (NBG), 2207 (PRE), 2208 (S), 2209 (NH, SAAS, STE).

ACKNOWLEDGEMENTS

I thank the Directors and staff of the cited herbaria for the loan of specimens. Dr H. F. Glen (Botanical Research Institute, Pretoria) kindly translated the diagnoses. The taxonomic study of *Lotononis* is a registered Ph. D. project at the University of Cape Town.

REFERENCES

- BENTHAM, G. 1843. Enumeration of Leguminosae, indigenous to southern Asia, and central and southern Africa. *The London Journal of Botany* 2: 594–613.
- DÜMMER, R.A. 1913. A synopsis of the species of *Lotononis*, Eckl. & Zeyh., and *Pleiospora* Harv. *Transactions of the Royal Society of South Africa* 3: 275–335.
- HARVEY, W.H. 1862. Leguminosae. In W.H. Harvey & O.W. Sonder, *Flora capensis* 2: 47–66. Hodges & Smith, Dublin.
- VAN WYK, B-E. 1989. Studies in the genus *Lotononis* (Crotalariaeae, Fabaceae). VIII. A new species of the *L. corymbosa* group and notes on the taxonomy of the section *Lipozygis*. *South African Journal of Botany* 55: 528–532.

Studies in the genus *Lotononis* (Crotalariaeae, Fabaceae). 12. Four new species of the *L. falcata* group, section *Leptis*

B-E. VAN WYK*

Keywords: Fabaceae, *Lotononis* section *Leptis*, new species, southern Africa

ABSTRACT

The taxonomic position of *Lotononis falcata* (E. Mey.) Benth. and related species is briefly discussed. These species were previously included in the section *Leptis* (Eckl. & Zeyh.) Benth. but new information indicates an affinity with the section *Oxydium* Benth. Four new species of this group are described: *L. fruticoides* B-E. van Wyk, *L. pachycarpa* Dinter ex B-E. van Wyk, *L. linearifolia* B-E. van Wyk and *L. schreiberi* B-E. van Wyk. The known geographical distribution and diagnostic characters of the new species are given.

UITTREKSEL

Die taksonomiese posisie van *Lotononis falcata* (E. Mey.) Benth. en verwante spesies word kortliks bespreek. Hierdie spesies is voorheen ingesluit in die seksie *Leptis* (Eckl. & Zeyh.) Benth. maar nuwe inligting dui op 'n verwantskap met die seksie *Oxydium* Benth. Vier nuwe spesies van hierdie groep word beskryf: *L. fruticoides* B-E. van Wyk, *L. pachycarpa* Dinter ex B-E. van Wyk, *L. linearifolia* B-E. van Wyk en *L. schreiberi* B-E. van Wyk. Die bekende geografiese verspreiding en diagnostiese kenmerke van die nuwe spesies word aangegee.

INTRODUCTION

A study of *Lotononis falcata* (E. Mey.) Benth. and its allies [previously included in the section *Leptis* (Eckl. & Zeyh.) Benth.] has shown the presence of four undescribed species. The purpose of this paper is to describe the new species and to show that the *L. falcata* group is better placed in the section *Oxydium* Benth. than in *Leptis*.

The original concept and limits of the genus *Leptis* Eckl. & Zeyh. were considerably broadened by Benth (1843) when he included it as a section within *Lotononis* (DC.) Eckl. & Zeyh. As presently circumscribed (Dümmer 1913), *Leptis* is undoubtedly an artificial group. It appears to have been used as a convenient position for species that did not seem to fit comfortably elsewhere.

Similarities and differences between the section *Oxydium* and various groups of the section *Leptis* are given in Table 1. The *L. laxa* and *L. falcata* groups clearly have more in common with *Oxydium* than with *Leptis sensu stricto*. This is indicated by chemical similarities as well as the subequally lobed calyx, the basally dilated standard petal, the strongly dimorphic anthers and the keel petals, which are often beaked. In the *L. falcata* group however, the keel petals are usually not distinctly beaked but all the other characters are typical for *Oxydium*. The panduriform shape of the standard petal (see Figures 1, 3–5) is a useful diagnostic character for the *L. falcata* group and the annual habit also distinguishes this group from *L. laxa* and related species.

Lotononis fruticoides B-E. van Wyk, sp. nov., *L. falcatae* valde affinis sed habitu valde robustiore (planta annua fruticiformis 0,3–0,6 m alta), pedunculis longis (*L. falcata* pedunculis \pm absentibus), inflorescentiis

plerumque 3-floris (plerumque 1- vel rarius 2-floris in *L. falcata*), foliolis angustioribus acutis, leguminibus valde brevioribus, distributione magis orientali differt.

TYPE.—Cape Province, 3224 (Graaff-Reinet): Naudesberg Pass, 39 km from Graaff-Reinet, 31.08.1986, Van Wyk 2020 (PRE, holo.; K, MO, NBG, SAAS, iso.).

Robust annual up to 0,6 m high and wide. *Branches* divaricate, rigid, sparsely leafy, glabrescent. All mature parts (except the corolla) sparsely and minutely strigillose. *Leaves* trifoliolate, (6–)12–25(–36) mm long; petiole \pm half as long as the terminal leaflet; leaflets very narrowly elliptic to linear, (4–)10–20(–30) \times (0,5–)1–2 mm, sparsely and inconspicuously strigillose on both surfaces. *Stipules* absent or when very rarely present then single at each node, linear, 1 mm long. *Inflorescences* leaf-opposed, distinctly pedunculate, umbellately (1–)3(–5)-flowered; peduncle short, (3–)5–10(–27) mm long; bracts minute, linear, \pm 0,5 mm long; bracteoles absent. *Flowers* 8–10 mm long, yellow; pedicel short, 1–1,5 mm long. *Calyx* subequally lobed but with the lower lobe narrower than the upper four, the sinuses of equal depth; lobes narrowly triangular, acute. *Standard* panduriform, as long as the keel; claw much dilated at the base, 2,5–3 \times 1–1,5 mm at the base, with a small central callosity; lamina 5–7 \times 4–5 mm, without lobes or callosities, glabrous but with a few minute hairs dorsally along the middle, often with a reddish brown line along the midrib. *Wing petals* oblong, slightly shorter than the keel, folded into a long shallow pocket near the base, glabrous; apex rounded; sculpturing indistinct or absent. *Keel petals* half oblong-elliptic, auriculate, glabrous; apex acute but not beaked. *Androecium* with the anthers markedly dimorphic; basifixed anthers linear, more than 2 \times longer than the small ovoid dorsifixed anthers; carinal anther intermediate in size and shape. *Gynoecium* subsessile; pistil ovoid-oblong, sparsely pubescent; style only slightly curved. *Pods* subsessile, shortly oblong, 10–14 \times 2,5–3,5 mm,

* Department of Botany, Rand Afrikaans University, P. O. Box 524, Johannesburg 2000.
MS. received 1989.06.06.

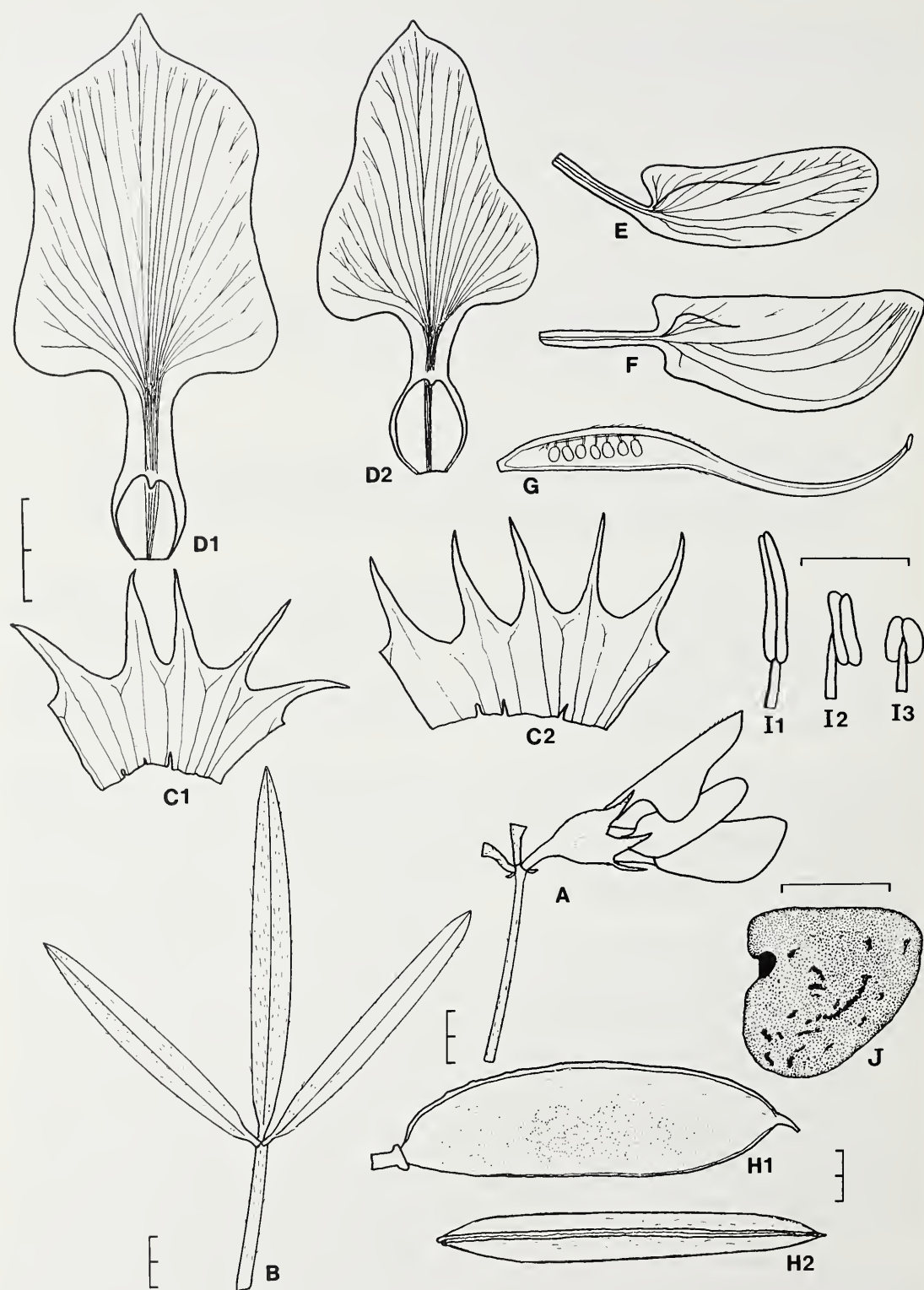


FIGURE 1.—*Lotononis fruticoides*. A, inflorescence and flower; B, leaf in adaxial view (note absence of stipules); C1 & C2, calyces opened out with the upper lobes to the left; D1 & D2, standard petals, showing the panduriform shape, dilated claw and central callosity; E, wing petal (note absence of sculpturing); F, keel petal; G, pistil; H1 & H2, pods: H1, in lateral view, H2, in top view; I1, I2 & I3, anthers: I1, basifixed anther, I2, carinal anther, I3, dorsifixed anther; J, seed, showing the tuberculate surface. All from Van Wyk 2020 except C2 & D1 from Schutte 220. Scales in mm.

TABLE 1.—Summary of similarities and differences between *Lotononis* section *Oxydium* and various groups of the section *Leptis*

	sect. <i>Oxydium</i>	<i>L. falcata</i> group	sect. <i>Leptis</i> <i>L. laxa</i> group	<i>L. calycina</i> group
Habit	annual or perennial	annual	perennial	annual or perennial
Juvenile leaves	often unifoliate	trifoliate	unifoliate	trifoliate
Calyx	subequally lobed	subequally lobed	subequally lobed	lateral sinuses shallower than upper and lower ones
Standard petal				
claw	dilated	dilated	dilated	not dilated
callosity	rarely present	often present	often present	absent
shape	suborbicular to ovate	panduriform	suborbicular to ovate	oblong
Wing petals	rarely pubescent	rarely pubescent	glabrous	pubescent
Keel petals	acute to beaked	obtuse to acute	acute to beaked	rounded
Anther length (basifixed: dorsifixed)	> 2 : 1	> 2 : 1	> 2 : 1	< 2 : 1
Hair type	biramous, rarely uniseriate	biramous, rarely uniseriate	biramous	uniseriate
Cyanogenesis	mostly cyanogenic	invariably cyanogenic	mostly cyanogenic	acyanogenic
Alkaloids	pyrrolizidine	pyrrolizidine	pyrrolizidine	quinolizidine

compressed, glabrous, apex somewhat cuspidate, upper suture ± smooth, ± 6-seeded, the seeds on 1,5–2 mm long funicles. *Seeds* subtriangular, ± 1,5 mm in diameter; testa pale yellow, often with dark purple marks, densely but minutely tuberculate (Figure 1).

L. fruticoides is closely related to *L. falcata*, but differs in the much more robust habit (a shrub-like annual of 0,3–0,6 m high), the long peduncles (peduncles ± absent in *L. falcata*), the predominantly 3-flowered inflorescences (usually 1- or rarely 2-flowered in *L. falcata*), the narrower and acute leaflets, the much shorter pods and in the more eastern distribution. A form of *L. falcata* from the Calvinia-Sutherland area is rather similar to *L. fruticoides* and may be confused with it, but in this form the leaflets are broadly obovate to oblanceolate and the habit totally different. *L. fruticoides* has been recorded only from the south-eastern regions of the Cape Province, where it appears to be very common (Figure 2). It is highly cyanogenic (Van Wyk 1989), and stock losses reported from the Beaufort West area (Burtt Davy 1912) may be due to this species rather than *Dichilus gracilis* Eckl. & Zeyh., with which it is often confused. The chromosome number of *L. fruticoides* (2n = 18) has been reported by Van Wyk & Schutte (1988) and the presence of pyrrolizidine alkaloids by Van Wyk & Verdoorn (1989).

CAPE.—3125 (Steynsburg): Middelburg division, Bangor Farm (–AC), *Bolus s.n. sub BOL 14075* (BOL). 3222 (Beaufort West): ± 80 km west of Beaufort West, back of the mountain on Farm Ezels Kom, adjoining the Farm Layton (–AB), *Shearing 1272* (JRAU); Karoo National Park, rocky plateau just above Wagenpad Dam (–AD), *Bengis 474* (PRE); Molteno Pass near Beaufort West (–BA), *Van Wyk 2137* (JRAU, NBG, PRE); start of Molteno Pass (–BC), *Schutte 219* (GRA, JRAU, K, MO, NBG, PRE), 220 (BOL, GRA, JRAU, PRE, SAAS, STE). 3223 (Rietbron): Courlands Kloof, Nelspoort (–AA), *Pearson 832* (NBG). 3224 (Graaff-Reinet): Naudesberg Pass, 39 km from Graaff-Reinet (–BA), *Van Wyk 2020* (PRE, holo.; JRAU, K, MO, NBG, iso.), 2021 (GRA, JRAU, PRE, S, SAAS), 2022 (JRAU, NBG, PRE), 2023 (BOL, BLFU, JRAU, STE), 2024 (JRAU, KMG, PRE, STE), 2025 (JRAU, M, NH, WIND), 2026 (JRAU); *C. M. van Wyk s.n.* (JRAU).

L. pachycarpa Dinter ex B-E. van Wyk, sp. nov.

L. pachycarpa Dinter in sched. *Amphinomia curtii* (Harms) Schreiber sensu Schreiber: 286 (1957), pro parte. *L. leptoloba* auct. non H. Bol.: Schreiber: 82 (1970).

L. linearifoliae valde affinis, sed foliis oblanceolatis vel obovatis (non linearibus), stipulis valde maioribus, pube patentiore, leguminibus ovoideis turgidibus. A *L. curtii* forma magnitudineque florum, vexilla panduriformi, pedicellis longioribus atque forma leguminum differt. Etiam cum *L. leptoloba* confusa est, sed species altera pedicellos brevissimos in pedunculis longis (pedicellus longus, pedunculo ± deficiente in *L. pachycarpa*) et flores omnino dissimiles magnitudine et forma habet. *L. leptoloba* habet alas valde longiores, vexillum valde maiorem omnino forma dissimilem, legumina oblongos (non ovoideos), et distributionem geographicam dissimilem.

TYPE.—Namibia, 2615 (Lüderitz): Halenberg, 29.08.1929, *Dinter 6648* (PRE, holo.; BM, BOL, K, M, SAM, STE, iso.).

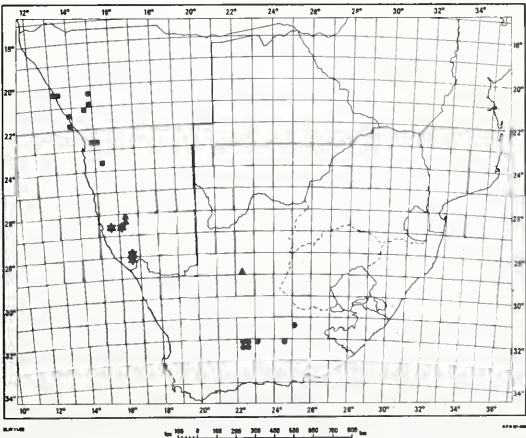


FIGURE 2.—The known geographical distribution of *Lotononis fruticoides*, ●; *L. pachycarpa*, ☆; *L. linearifolia*, ▲; and *L. schreiberi*, ■.

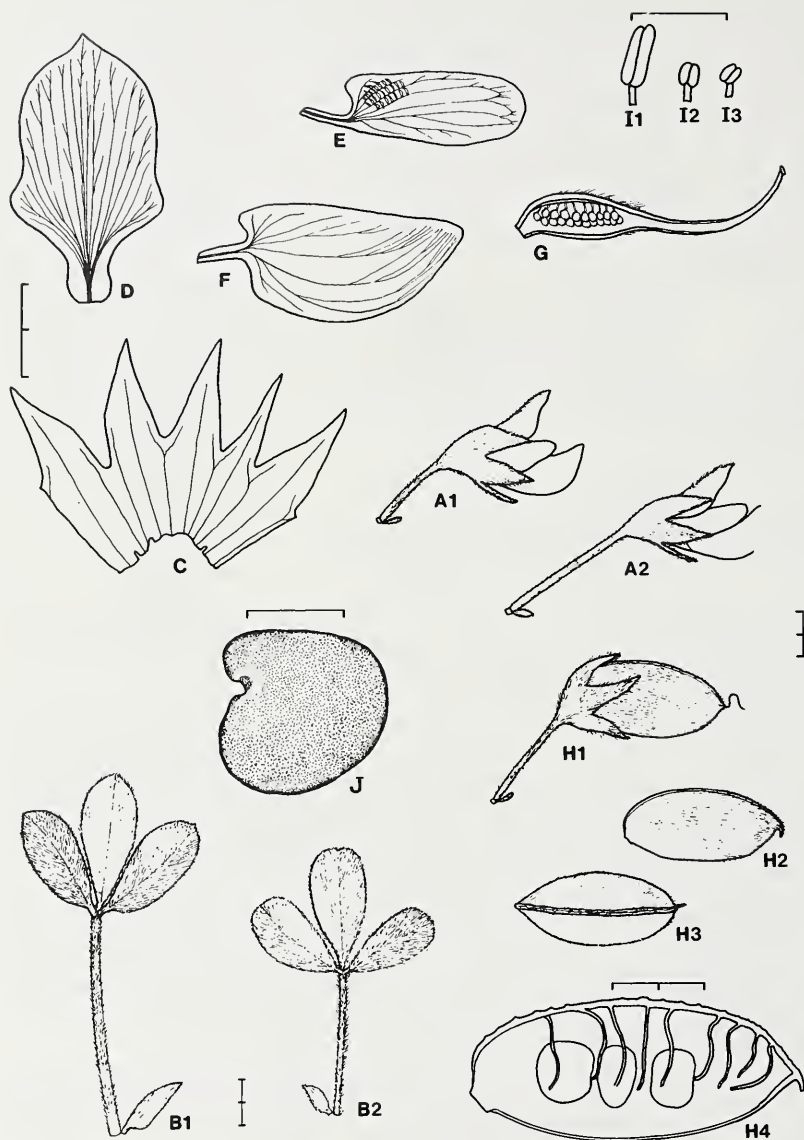


FIGURE 3.—*Lotononis pachycarpa*.

A1 & A2, inflorescences and flowers (note the long pedicels); B1 & B2, leaves in adaxial view; C, calyx opened out with the upper lobes to the left; D, standard petal; E, wing petal; F, keel petal; G, pistil; H1, H2, H3 & H4, pods: H1 & H2, in lateral view, H3, in top view, H4, after dehiscence as viewed from inside (note verrucose upper suture and long funicles); I1, I2 & I3, anthers: I1, basifixed anther, I2, carinal anther, I3, dorsifixed anther; J, seed, showing the tuberculate surface. A1 from Dinter 4070; A2, B2, H1, H2, H3 & H4 from Dinter 6648; C, D, E, F, G, I1, I2 & I3 from Merxmüller & Giess 28505; B1 & J from Giess, Volk & Bleissner 5462. Scales in mm.

Small annual up to 0,1 m high and up to 0,3 m wide. Branches divaricate, slender, sparsely leafy. All mature parts (except the corolla) densely but minutely silky-strigillose. Leaves trifoliolate, (6–)8–16(–26) mm long; petiole long or longer than the terminal leaflet; leaflets oblanceolate to obovate, (2–)4–8(–14) × (1–)2–3 mm, sparsely silky-strigillose on both surfaces. Stipules single at each node, small, lanceolate, 1–3(–4) mm long. Inflorescences leaf-opposed, invariably single-flowered; peduncle ± absent, up to 0,5 mm long; bracts very small, linear, up to 1,5 mm long; bracteoles absent. Flowers small, 4,5–7 mm long, yellow; pedicel long and slender, as long or longer than the calyx, up to 10 mm long. Calyx subequally lobed but with the lower lobe a little narrower than the upper four and the lateral sinuses slightly shallower than the upper and lower ones; lobes triangular, acute. Standard broadly panduriform, as long as the keel; claw very short, slightly dilated at the base, 1–2 × ± 1 mm, without callosities; lamina 4–5 × 3–4 mm, without lobes or callosities, glabrous but with a few hairs

dorsally along the middle. Wing petals oblong, slightly shorter than the keel; apex rounded; sculpturing in ± 3 rows of intercostal lunae fading into a few transcostal lamellae towards the auricle. Keel petals subtriangular, auriculate, glabrous; apex acute but not beaked. Androecium with the anthers markedly dimorphic; basifixed anthers oblong, more than 3x longer than the small ovoid dorsifixed anthers; carinal anther slightly larger than the dorsifixed anthers. Gynoecium subsessile; pistil ovoid-oblong, pubescent; style only slightly curved. Pods subsessile, small, ovoid, 6–10 × 3–4 mm, much inflated laterally, minutely silky-strigillose, apex obtuse, upper suture minutely but distinctly verrucose, 8–15-seeded, the seeds on up to 2 mm long funicles. Seeds suborbicular, ± 1,5 mm in diameter; testa brown, densely but minutely tuberculate (Figure 3).

L. pachycarpa is closely related to *L. linearifolia*, but differs in the oblanceolate (not linear) leaflets, the much

larger stipules, the more spreading vestiture and the ovoid, turgid pods (Figure 3). From *L. curtii* it differs in the shape and size of the flowers, the panduriform standard petal, the longer pedicels and also in the shape of the pods. It has also been confused with *L. leptoloba* (Schreiber 1970) but the inflorescence structure is only superficially similar (a long pedicel with the peduncle \pm absent in *L. pachycarpa*; a short pedicel on a long peduncle in *L. leptoloba*). The flowers are also totally different in size and structure. *L. leptoloba* has much longer wing petals, a much larger and differently shaped standard petal, oblong (not ovoid) pods, and a different geographical distribution. *L. pachycarpa* occurs in southern Namibia (Figure 2), whereas *L. leptoloba* has been recorded only from the western and north-western parts of the Cape Province.

NAMIBIA.—2615 (Lüderitz): Halenberg (—DA), Dinter 4070 (BOL, PRE, SAM), 6648 (PRE, holo.; BM, BOL, K, M, SAM, STE, iso.). 2616 (Aus): 12 miles [19,2 km] west of Aus on the way to Lüderitz (—CA), Giess, Volk & Bleissner 5462 (PRE, M, MO, WIND). 2716 (Witputz): 9 km N of Rosh Pinah (—DC), Merxmüller & Giess 28505 (M, WIND). 2816 (Oranjemund): Namib, west of Obibberge, 14 km S of Obib Wasser (—BA), Merxmüller & Giess 32363 (M).

***L. linearifolia* B-E. van Wyk, sp. nov.**, *L. pachycarpae* similis, sed foliolis gracilibus linearibus, stipulis inconspicuis, pube breviori plus arcte appressa ac leguminibus oblongo-linearibus tantum parum inflatis differt. Etiam similis est *L. falcatae*, sed ab illa speciebusque affinis pedicello longo gracili (calyce longiore) ac foliolis anguste linearibus, plus dense sericeo-strigillosis differt.

TYPE.—Cape Province, 2822 (Glen Lyon): Hay 0.303 [see map in Wilman (1946)], 09.07.1936, *Acocks* 506 (PRE, holo.; BOL, KMG, PRE, iso.).

Very small annual up to 0,1 m high and 0,25 m wide. Branches procumbent, slender, sparsely leafy. All mature parts (except the corolla) densely but minutely strigillose. Leaves trifoliate, slender, (12–)18–28(–42) mm long; petiole usually very much longer than the terminal leaflet; leaflets very narrowly oblanceolate or usually linear, (4–)6–14(–18) \times (0,5–)1–1,2(–2) mm, densely but minutely strigillose on both surfaces. Stipules single at each node, inconspicuous, linear, up to 1 mm long. Inflorescences leaf-opposed, invariably single-flowered; peduncle \pm absent, up to 0,5 mm long; bracts very small, linear, up to 1 mm long; bracteoles absent. Flowers small, 4,5–7 mm long, yellow; pedicel long and slender, as long or much longer than the calyx, up to 8 mm long. Calyx subequally lobed but with the lower lobe a little narrower than the upper four and the lateral sinuses slightly shallower than the upper and lower ones; lobes triangular, acute. Standard broadly panduriform, as long as the keel; claw short, slightly dilated at the base, \pm 1,5 \times \pm 1 mm, with a central callosity; lamina \pm 4,5 \times \pm 3 mm, without lobes or callosities, glabrous but with a few hairs dorsally along the middle. Wing petals oblong, slightly shorter than the keel; apex rounded; sculpturing in \pm 3 rows of intercostal lunae fading into a few transcostal lamellae towards the auricle. Keel petals shortly oblong, auriculate, glabrous; apex acute but not beaked. Androecium with the anthers markedly dimorphic; basifixed anthers oblong, more than 3 \times longer than the small ovoid dorsifixed

anthers; carinal anther slightly larger than the dorsifixed anthers. Gynoecium subsessile; pistil oblong, pubescent; style curved upwards. Pods subsessile, oblong to linear, (8–)10–14 \times 2,5–3 mm, not inflated laterally, minutely strigillose, apex obtuse, upper suture distinctly and evenly verrucose, 10–15-seeded, the seeds on up to 1,5 mm long funicles. Seeds suborbicular, \pm 1,2 mm in diameter; testa brown, densely but minutely tuberculate (Figure 4).

A distinct species, similar to *L. pachycarpa* but differs in the slender, linear leaflets, the inconspicuous stipules, the shorter and more closely appressed vestiture and the oblong-linear and only slightly inflated pods. It is also similar to *L. falcata*, but differs from this and related species in the long slender pedicel (much longer than the calyx) and the linear, densely silky-strigillose leaflets (Figure 4).

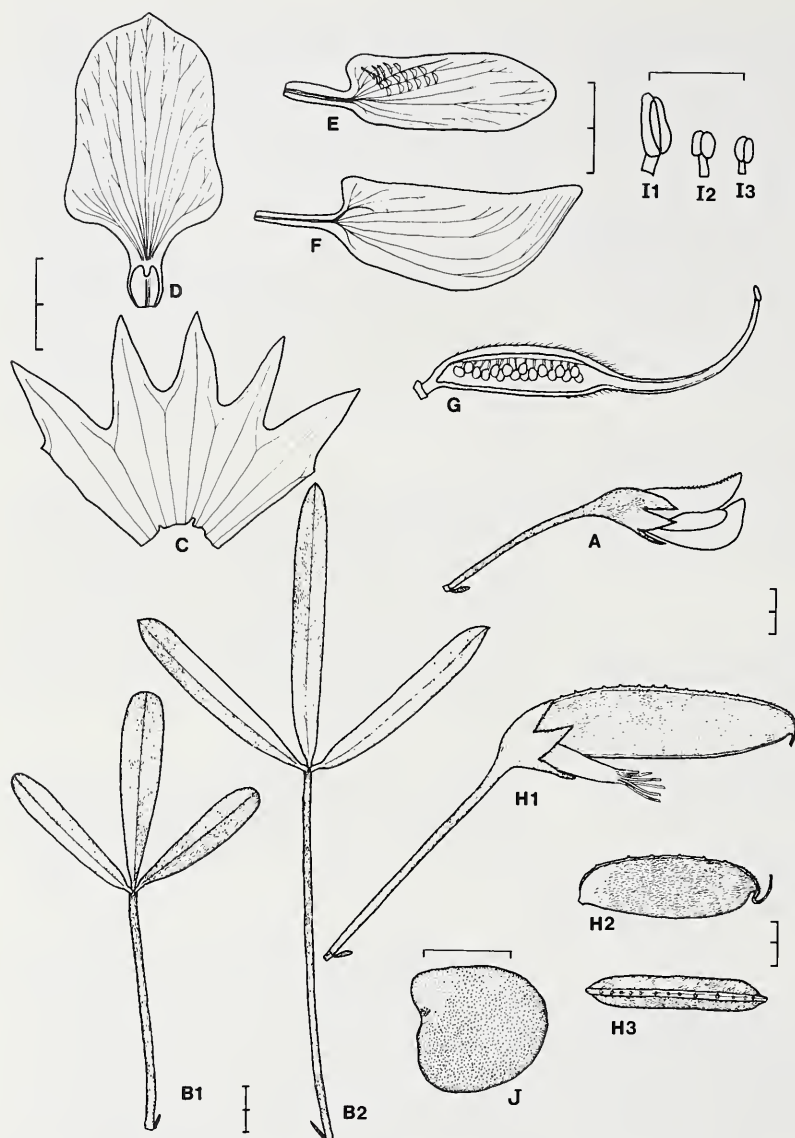
L. linearifolia was listed as an unidentified species by Wilman (1946: 52) and the two specimens from Namibia were cited by Schreiber (1970: 82) as perhaps belonging to *L. leptoloba* sensu Schreiber (= *L. pachycarpa*). It is highly cyanogenic (Van Wyk 1989) and, according to notes on the Kinges specimen in M, is said to have caused sheep losses. The only known localities (southern Namibia and the northern Cape) are given in Figure 2, but the species is probably not as rare as the scanty herbarium record would suggest.

NAMIBIA.—2616 (Aus): Lüderitz District, Farm Weissenborn (—AB), Kinges 2433 (M); Namib plain between Neisip and Eureka (—AD), Merxmüller & Giess 2876 (M). 2822 (Glen Lyon): Hay 0.303 [near the Orange River W of Groblershoop, see map in Wilman (1946)] (—CD), *Acocks* 506 (PRE, holo.; BOL, KMG, PRE, iso.).

***L. schreiberi* B-E. van Wyk, sp. nov.**, species distincta sine affinitatibus manifestis. *L. leptolobae* superficialiter similis, sed stipulis perpusillis inconspicuis, pedunculo subnullo, vexillo panduriformi (non late cordato) conspicue striato pubescenti, apice acuto (non obtuso) basi dilatato, antheris plus valde dimorphis, leguminibus breviter ellipticis (non oblongis) cum \pm 12–15 seminibus (non \pm 30 seminibus) differt. Etiam *L. falcatae* speciebusque affinis similis, sed ab illis speciebusque omnibus sectionis *Oxydii* alis carinisque pubescentibus differt.

TYPE.—Namibia, 2113 (Cape Cross): Cape Cross, about 0,5 km from the coast, 29.04.1965, *Giess* 8707 (PRE, holo.; K, M, WIND, iso.).

Small annual up to 0,1 m high and 0,3 m wide. Branches prostrate, divaricate, often densely leafy. All mature parts densely to sparsely pubescent. Leaves trifoliate, variable in size, (7–)10–20(–28) mm long; petiole as long or often much longer than the terminal leaflet; leaflets oblanceolate to obovate, (3–)5–10(–14) \times (2–)3–5(–7) mm; vestiture very variable, densely to sparsely pubescent on both surfaces, adaxial surface glabrescent and often totally glabrous at maturity. Stipules single at each node, minute and inconspicuous, linear, up to 2 mm long. Inflorescences leaf-opposed, single-flowered, very rarely 2-flowered; peduncle \pm absent, up to 0,5 mm long; bracts very small and inconspicuous, linear, up to 1 mm long; bracteoles absent. Flowers 9–11 mm long, yellow;

FIGURE 4. —*Lotononis linearifolia*.

A, inflorescence and flower (note the long pedicel); B1 & B2, leaves in adaxial view; C, calyx opened out with the upper lobes to the left; D, standard petal, showing the panduriform shape of the lamina, dilated claw and central callosity; E, wing petal; F, keel petal; G, pistil; H1, H2 & H3, pods (note verrucose upper suture): H1 & H2, in lateral view, H3, in top view; I1, I2 & I3, anthers: I1, basifixed anther, I2, carinal anther, I3, dorsifixed anther; J, seed, showing the tuberculate surface. All from Acocks 506 except B1 from Merxmüller & Gies 2876 and H2, H3 & J from Kinges 2433. Scales in mm.

pedicel short, 2–3 mm long. *Calyx* subequally lobed; lobes long, very narrowly triangular, acute. *Standard* broadly panduriform, as long as the keel; claw short, slightly dilated at the base, $\pm 2 \times \pm 1,5$ mm, often with an inconspicuous central callosity; lamina 7–9 \times 4–5 mm, without lobes or callosities, strongly striated, dorsal surface densely pubescent; apex tapering to an acuminate tip. *Wing petals* narrowly oblong, slightly shorter than the keel, distinctly auriculate, pubescent along the lower margin; apex rounded; sculpturing in ± 5 rows of intercostal lunae. *Keel petals* oblong, distinctly auriculate, pubescent along the lower half, strongly striated; apex obtuse. *Androecium* with the anthers markedly dimorphic; basifixed anthers oblong, more than $2 \times$ longer than the ovoid dorsifixed anthers; carinal anther slightly larger than the dorsifixed anthers. *Gynoecium* sessile; pistil oblong, densely pubescent; style long and slender, upper part curved upwards. *Pods* subsessile, shortly oblong, 8–10 \times 3–3,5 mm, only slightly inflated laterally, pubescent, apex obtuse, upper suture distinctly verrucose,

12–15-seeded, the seeds on up to 1,5 mm long funicles. *Seeds* suborbicular, $\pm 1,2$ mm in diameter; testa brown, densely tuberculate (Figure 5).

This species (named after Dr Annelis Schreiber of the Botanische Staatssammlung München) was listed as *L. spec.* (no. 18) in the *Prodromus einer Flora von Südwestafrika* (Schreiber 1970). *L. schreiberi* is a very distinct new species and has no obvious affinities. The relatively large flowers, pubescent and striated petals and single-flowered inflorescences are useful diagnostic characters (Figure 5). It is superficially similar to *L. leptoloba*, but differs in the very small, inconspicuous stipules, the panduriform (not broadly cordate) and conspicuously striated, pubescent standard petal, with an acute (not obtuse) apex and a dilated base, the more markedly dimorphic anthers, the shortly elliptic (not oblong) pods that are ± 12 –15-seeded (not ± 30 -seeded). It is also superficially similar to *L. falcata* and related species, but

differs from these and all other species of the section *Oxydium* in the pubescent wing and keel petals (*L. arenicola* Schltr. is the only species of *Oxydium* with pubescent wing and keel petals but the morphology of this species is totally different). Several collections of *L. schreiberi* have been made in the north-western parts of Namibia, where it appears to be quite common (Figure 2).

NAMIBIA. —2013 (Unjab Mouth): Skedelkuspark (—AC), *Venter* 9025 (BLFU); 23 km SE of Torra Bay (—AD), *Giess* 8020 (M, PRE, WIND); 14 miles [22.4 km] E of Torra Bay (—AD), *Giess, Volk & Bleissner* 6277 (M, PRE, WIND); 15 miles [24 km] SE of Torra Bay (—AD), *Nordenstam* 3789 (M). 2014 (Welwitschia): Welwitsch, Damaraland (—BD), *Galpin & Pearson* sub *Galpin* 7547 (PRE, SAM); koppies S of Ugab River Station (—DD), *Müller & Louit* 1096 (M, WIND). 2113 (Cape Cross): flats a few miles inland on road to Brandberg West Mine (—BD), *Oliver & Müller* 6660 (PRE, partly); Cape Cross, about 0.5 km from the coast (—DD), *Giess* 8707 (PRE, holo.; K, M, WIND, iso.). 2114 (Uis): S of the Messumberge \pm 12 miles [19.2 km] E of the coast (—BA), *Giess* 3576 (PRE, WIND). 2214 (Swakopmund): track from Goanicones to Rossing Mountain (—DB), *Kers* 1311 (WIND). 2215 (Trekopje): Farm Nordenberg, Swakop River at Tsavischab (—CA), *Kers* 4 (WIND); Swakop River, along the track from Swakop

at Tsavischab to Farm Nordenberg and Karibib (—CA), *Kers* 1532 (WIND). 2315 (Rostock): Kuiseb River, SE of Hope Mine, on the Namib plain between Hope Mine and Garob Mine (—CB), *Kers* 1580, 1586 (WIND).

ACKNOWLEDGEMENTS

I thank Dr H. F. Glen (Botanical Research Institute, Pretoria) for the Latin translations and the Directors and staff of the cited herbaria for the loan of specimens. The taxonomic study of *Lotononis* is a registered Ph. D. project at the University of Cape Town.

REFERENCES

- BENTHAM, G. 1843. Enumeration of Leguminosae, indigenous to southern Asia, and central and southern Africa. *Hooker's, London Journal of Botany* 2: 472–481, 559–613.
- BURTT DAVY, J. 1912. Botanical investigations into gal-lamziekte. *Reports of the Veterinary Research Institute of South Africa* 2: 181–196.

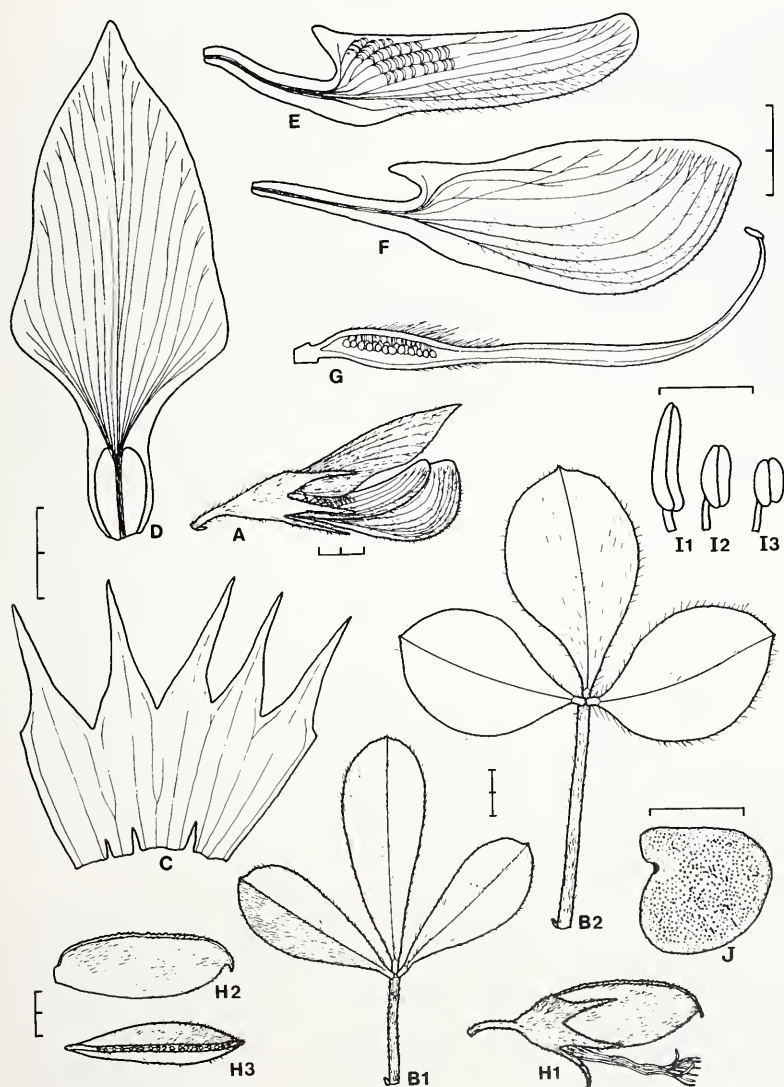


FIGURE 5.—*Lotononis schreiberi*.

A, inflorescence and flower (note the absence of a peduncle); B1 & B2, leaves in adaxial view, showing the variation in pubescence and leaflet shape (note the small stipules); C, calyx opened out with the upper lobes to the left; D, standard petal, showing the panduriform shape of the lamina, dilated claw and central callosity; E, wing petal (note vestiture); F, keel petal (note vestiture); G, pistil; H1, H2 & H3, pods (note verrucose upper suture); H1 & H2, in lateral view, H3, in top view; I1, I2 & I3, anthers: I1, basifixed anther, I2, carinal anther, I3, dorsifixed anther; J, seed, showing the tuberculate surface. All from *Giess* 8020 except B1, C, D, E, F & G from *Kers* 1586. Scales in mm.

- DÜMMER, R.A. 1913. A synopsis of the species of *Lotononis*, Eckl. & Zeyh., and *Pleiospora* Harv. *Transactions of the Royal Society of South Africa* 3: 275–335.
- SCHREIBER, A. 1957. *Amphinomia* DC. *Mitteilungen aus der Botanischen Staatssammlung, München* 2: 286–289.
- SCHREIBER, A. 1970. Fabaceae. In H. Merxmüller, *Prodromus einer Flora von Südwestafrika* 60: 76–85. Cramer, Lehre.
- VAN WYK, B-E., 1989. The taxonomic value of cyanogenesis in *Lotononis* and related genera. *Biochemical Systematics and Ecology* 17: 297–303.
- VAN WYK, B-E. & SCHUTTE, A. L. 1988. Chromosome numbers in *Lotononis* and *Buchenroedera* (Fabaceae–Crotalariaeae). *Annals of the Missouri Botanical Garden* 75: 1603–1607.
- VAN WYK, B-E. & VERDOORN, G. H. 1989. A chemotaxonomic survey of major alkaloids in *Lotononis* and *Buchenroedera*. *Biochemical Systematics and Ecology* 17: 385–389.
- WILMAN, A. 1946. *Preliminary checklist of the flowering plants and ferns of Griqualand West*. Deighton Bell, Cambridge.

Studies in the genus *Lotononis* (Crotalariaeae, Fabaceae). 13. Two new species and notes on the occurrence of cleistogamy in the section *Leptis*

B-E. VAN WYK*

Keywords: cleistogamy, Fabaceae, flower dimorphism, *Lotononis* section *Leptis*, new species

ABSTRACT

The occurrence of flower dimorphism in the genus *Lotononis* (DC.) Eckl. & Zeyh. is reported for the first time. Cleistogamous flowers have been observed in 12 species from four different groups of the sections *Leptis* (Eckl. & Zeyh.) Benth. and *Oxydium* Benth. Morphological differences between chasmogamous and cleistogamous flowers are discussed and illustrated. The phenomenon of flower dimorphism appears to be of limited taxonomic value but nevertheless supports the idea of an affinity between the *L. laxa*, *L. pungens* and *L. leptoloba* groups. Two recently discovered new species of the *L. leptoloba* and *L. calycina* groups, *L. venosa* B-E. van Wyk and *L. acuticarpa* B-E. van Wyk, are described.

UITTREKSEL

Die voorkoms van blomdimorfisme in die genus *Lotononis* (DC.) Eckl. & Zeyh. word vir die eerste keer gerapporteer. Kleistogame blomme is by 12 spesies van vier verskillende groepe van die seksies *Leptis* (Eckl. & Zeyh.) Benth. en *Oxydium* Benth. waargeneem. Morfologiese verskille tussen chasmogame en kleistogame blomme word bespreek en geïllustreer. Die verskynsel van blomdimorfisme is klaarblyklik van beperkte taksonomiese waarde maar ondersteun nietemin die idee van 'n verwantskap tussen die *L. laxa*-, *L. pungens*- en *L. leptoloba*-groepe. Twee nuwe spesies van die *L. leptoloba*- en *L. calycina*-groepe wat onlangs ontdek is, *L. venosa* B-E. van Wyk en *L. acuticarpa* B-E. van Wyk, word beskryf.

INTRODUCTION

The occurrence of flower dimorphism in the genus *Lotononis* (DC.) Eckl. & Zeyh. is reported here for the first time. Morphological differentiation between chasmogamous and cleistogamous flowers appears to be restricted to the sections *Leptis* (Eckl. & Zeyh.) Benth. and *Oxydium* Benth. As presently circumscribed (Bentham 1843; Dümmer 1913), *Leptis* was recently shown to be an artificial group and it was suggested that some species would be much better placed in *Oxydium* (Van Wyk 1990). The taxonomic value of cleistogamy is briefly discussed and two recently discovered new species of *Leptis sensu lato* are described below.

Cleistogamy has been reported from several genera of the Fabaceae (Uphof 1938; Arroyo 1981). Precocious bud pollination, with little or no effect on flower morphology, is known to occur in *Lotononis bainesii* Bak.f. (Byth 1964) and in the genus *Dichilus* DC. (Schutte 1988) and may be more common in the Crotalariaeae than was previously recognized. Morphological differentiation between cleistogamous and non-cleistogamous flowers of the same species however, is less common (Arroyo 1981). Flower dimorphism in the genus *Argyrolobium* Eckl. & Zeyh. was discussed in detail by Harms (1909, 1917) but no reports for other genera of the tribe Crotalariaeae could be found.

FLOWER DIMORPHISM IN *LOTONONIS*

Dimorphic flowers were observed in 12 species of the sections *Leptis* and *Oxydium* (Table 1). Unlike precocious bud-pollination, which is difficult to observe (and which probably occurs in many species of *Lotononis*), flower dimorphism is readily detected in herbarium material.

Bud-cleistogamy in the species listed in Table 1 results in a marked reduction in the size of the corolla, androecium and style but has only a slight effect on the calyx. The corolla does not open, but is usually pushed out of the calyx by the developing ovary. Figure 1 shows a typical example of flower dimorphism in *Lotononis*—the two flowers illustrated are from different branches of a single plant. It is also possible to recognize (by the remains of the style) those pods which were formed from cleistogamous flowers. The size and shape of the pods and

TABLE 1.—Flower dimorphism in various groups of the sections *Leptis* and *Oxydium*. The occurrence, observed frequency and degree of differentiation are indicated

Group and species	Frequency	Degree of differentiation
Section <i>Oxydium</i> Benth.:		
<i>Lotononis</i>		
<i>sparsiflora</i> (E. Mey.)		
B-E. van Wyk	rare	slight
<i>micrantha</i> Eckl. & Zeyh.	rare	slight
Section <i>Leptis</i> (Eckl. & Zeyh.) Benth.:		
<i>Lotononis</i>		
<i>L. calycina</i> group:		
<i>acuticarpa</i> B-E. van Wyk	rare	slight
<i>L. leptoloba</i> group:		
<i>leptoloba</i> H. Bol.	common	distinct
<i>maximiliani</i> Schltr.	common	distinct
<i>L. tenella</i> group:		
<i>tenella</i> (E. Mey.) Eckl. & Zeyh.	very common	distinct
<i>pungens</i> Eckl. & Zeyh.	very common	distinct
<i>L. laxa</i> group:		
<i>laxa</i> Eckl. & Zeyh.	common	distinct
<i>macrosepala</i> Conr.	very common	distinct
<i>crumanina</i> Burch. ex Benth.	very common	slight
<i>burchellii</i> Benth.	very common	slight
<i>maculata</i> Dümmer	very common	slight

* Department of Botany, Rand Afrikaans University, P. O. Box 524, Johannesburg 2000.
MS. received: 1989.06.06.

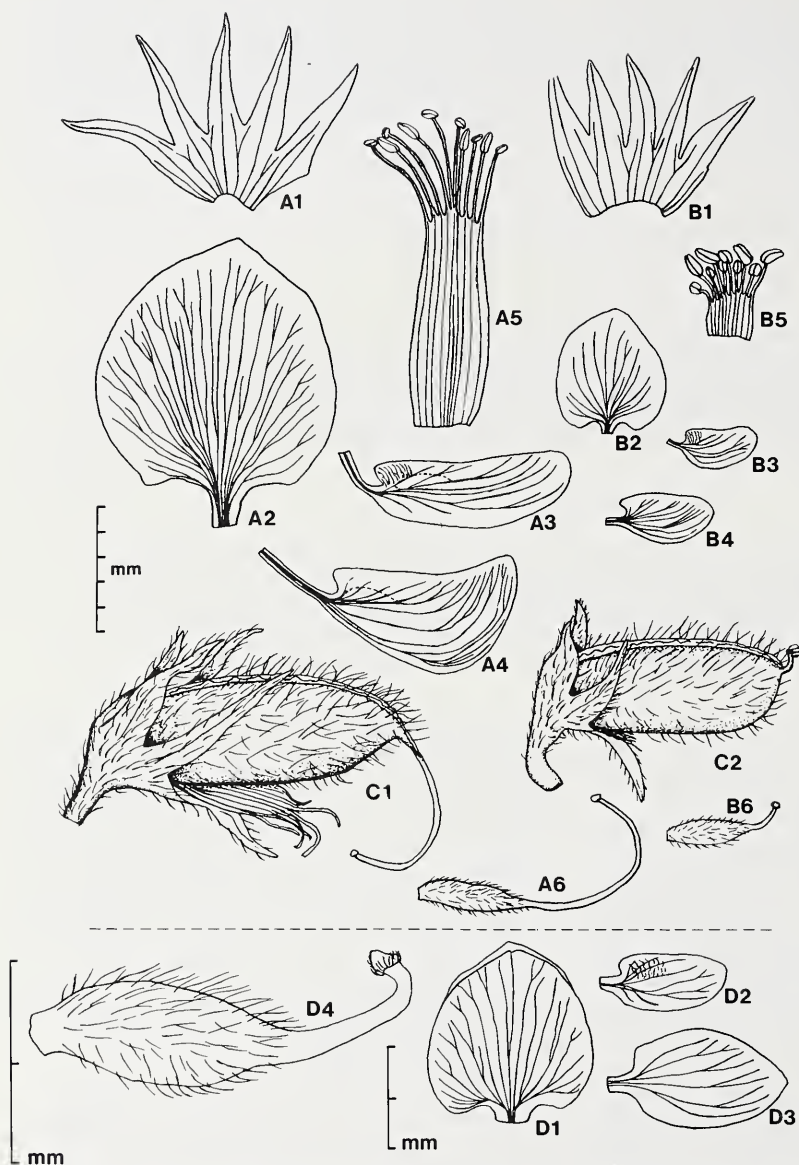


FIGURE 1.—Flower and fruit dimorphism in *Lotononis pungens*. Morphological differences between flowers and pods taken from the same individual (Van Wyk 1966b, JRAU) are shown above, and details of a cleistogamous flower from Schutte 215 (JRAU) below. A1–A6, chasmogamous flower: A1, calyx opened out with upper lobes to the left; A2, standard petal; A3, wing petal; A4, keel petal; A5, androecium; A6, pistil. B1–B6, cleistogamous flower: B1, calyx; B2, standard petal; B3, wing petal; B4, keel petal; B5, androecium; B6, pistil. C1 & C2, pods: C1, pod formed from a chasmogamous flower; C2, pod formed from a cleistogamous flower (note the small hooked stylar tissue and the anthers adhering to the stigma). D1–D4, cleistogamous flower: D1, standard petal; D2, wing petal (note sculpturing); D3, keel petal; D4, pistil.

the number of seeds are apparently not affected, but the old stylar tissue is short and hooked, often with one or more anthers adhering to the stigma. Scanning electron microscope studies have shown that pollen tubes grow right through the anther wall and into the stigma, thereby firmly attaching the anther to the stigma. Cleistogamy in *Lotononis* seems identical to that described in species of *Lespedeza* Mich. (Hanson & Cope 1955) and in *Ornithopus* L. (Wojciechowska 1972).

It is obvious that the 12 species listed in Table 1 are only facultatively cleistogamic and that they show no particular adaptation towards cleistogamy. The presence of petal sculpturing for example, indicates that the normal development of the flower bud is arrested at a relatively late stage of development. Furthermore, the occurrence of both flower forms at the same locality (and even on a single specimen) shows that cleistogamy is not a permanent condition. It is nevertheless significant that there is a clear

difference between cleistogamous and non-cleistogamous flowers—intermediate stages are rare or absent. Many factors are known to cause cleistogamy (Uphof 1938; Erickson 1975) and it may be worthwhile to gain experimental evidence for the mechanisms that influence cleistogamy in *Lotononis*. Personal observations have indicated that it is a seasonal phenomenon (at least in *L. laxa*) and that it may be induced by unfavourable climatic conditions.

Cleistogamy is generally considered to have limited value as a taxonomic character because of its variability and the likelihood of convergence (Uphof 1938). In the genus *Lotononis*, it has indeed led to taxonomic errors, such as a confusion between *L. calycina* (E. Mey.) Benth. and cleistogamous forms of *L. tenella* (Harvey 1862). The former is not cleistogamous but the very short corolla results in a superficial similarity with *L. tenella*. Early bud-cleistogamy (i.e. that which leads to dimorphic

flowers) does not appear to be randomly distributed in *Lotononis*. A direct relationship between the section *Oxydium* and some groups of the section *Leptis* is indicated, and other characters were shown to support this idea (Van Wyk 1990). Paradoxically, most of the species with dimorphic flowers have acute or beaked keel petals, a character that is more readily associated with outcrossing because it promotes an increased efficiency in the transfer of pollen. This remarkable versatility may partly explain why *L. laxa* and *L. tenella* have a wider geographical distribution than most other perennial species of *Lotononis*.

The two new species described below clearly illustrate that cleistogamy has limited value as a taxonomic character. *L. venosa* B-E. van Wyk is apparently not cleistogamic but is here placed in the *L. leptoloba* group, while *L. acuticarpa* B-E. van Wyk is the only species of the *L. calycina* group known to display at least some degree of flower dimorphism (see Table 1).

***Lotononis venosa* B-E. van Wyk, sp. nov., *L. leptolobae* H. Bol. affinis sed habitu minore foliosiore, foliis anguste oblongis vel linearibus (in *L. leptoloba* obovatis) stipulis geminis disperse dispositis (in *L. leptoloba* semper singularis), floribus leguminibusque valde maioribus differt.**

TYPE.—Cape Province, 3220 (Sutherland): De Hoop in Klein Roggeveld, 06.09.1986, *Oliver 8965* (PRE, holo.; STE, iso.).

Small prostrate annual up to 0,2 m wide. *Branches* densely leafy; twigs sparsely pilose with long spreading hairs. *Leaves* digitately trifoliate, very variable in size, sparsely pilose with long spreading hairs; petioles slightly winged, as long as the terminal leaflet or longer, (2–) 3–7(–16) mm long; leaflets narrowly oblong to linear, (2–) 5–12(–14) × (0,5–) 1–2(–2,5) mm, abaxially sparsely pilose, adaxially glabrescent. *Stipules* large, consistently present, single at each node or rarely paired at some nodes, oblong to narrowly oblong and often slightly falcate, similar to the leaflets or much larger, (2–) 6–12(–14) × (0,5–) 1,5–2,5(–3,5) mm. *Inflorescences* subterminal and leaf-opposed towards the branch ends, invariably single-flowered; peduncle usually ± as long as the calyx, (3–) 6–8(–12) mm long; bracts relatively large, narrowly linear, 5–8 mm long; bracteoles absent. *Flowers* large, 16–20 mm long, pale yellow with grey venation; pedicel short, ± 2 mm long. *Calyx* almost as long as the corolla, equally lobed, sparsely pilose; lobes very long and slender. *Standard* very large, broadly ovate; claw 4–5 mm long, very slightly dilated at the base, dilated part up to 1,8 mm wide; lamina acute, cordate at the base, 13–15 × 13–16 mm, glabrous but with a line of hairs dorsally along the middle. *Wing petals* oblong, much longer than the keel, glabrous, apex obliquely truncate; sculpturing in 4–5 rows of thin transcostal lunae and lamellae. *Keel petals* small, semi-circular, acute but not beaked, auriculate and pocketed near the base, glabrous. *Anthers* dimorphic, basifixed anthers 2× longer than the dorsifixed anthers, carinal anther similar to dorsifixed anthers. *Pistil* 11–13 mm long; ovary oblong, ± 6 mm

long, densely pubescent; style sharply curved. *Immature pods* oblong, slightly turgid, longer than the calyx, up to 18 × 5 mm, ± 30-seeded, upper suture distinctly verrucose, sparsely pilose; funicles up to 2 mm long. *Seed* unknown (Figure 2).

L. venosa is a distinct species known only from two recent collections in the Roggeveld area (Figure 4). The annual habit, general morphology, inflorescence structure and flower morphology are very similar to that of *L. leptoloba*. It differs, however, from this species in its smaller, leafier habit, its narrowly oblong to linear leaves (obovate in *L. leptoloba*), stipules which may be paired (in *L. leptoloba* always single), and in the much larger flowers and pods. Although there is no evidence of cleistogamy in this species and mature pods are unknown, it is placed in the affinity of *L. leptoloba* with some confidence. The flowers turn from yellow to a bluish colour when dried and the species may therefore be mistaken for *L. maximiliani* Schltr., but the shape of the leaflets and the very large flowers (Figure 2) are quite distinct.

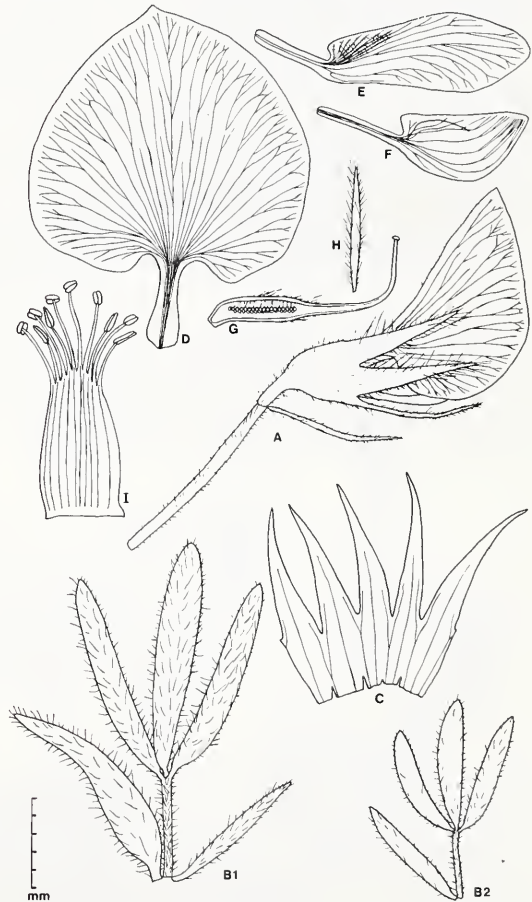


FIGURE 2. —*Lotononis venosa*. A, flower in lateral view showing the long peduncle and the vestiture of the calyx and standard petal; B1 & B2, leaves in adaxial view, showing paired stipules (B1) and a single stipule (B2); C, calyx opened out, upper lobes to the left (vestiture not shown); D, standard petal; E, wing petal; F, keel petal; G, pistil; H, bract; I, androecium. All from *Oliver 8965*.

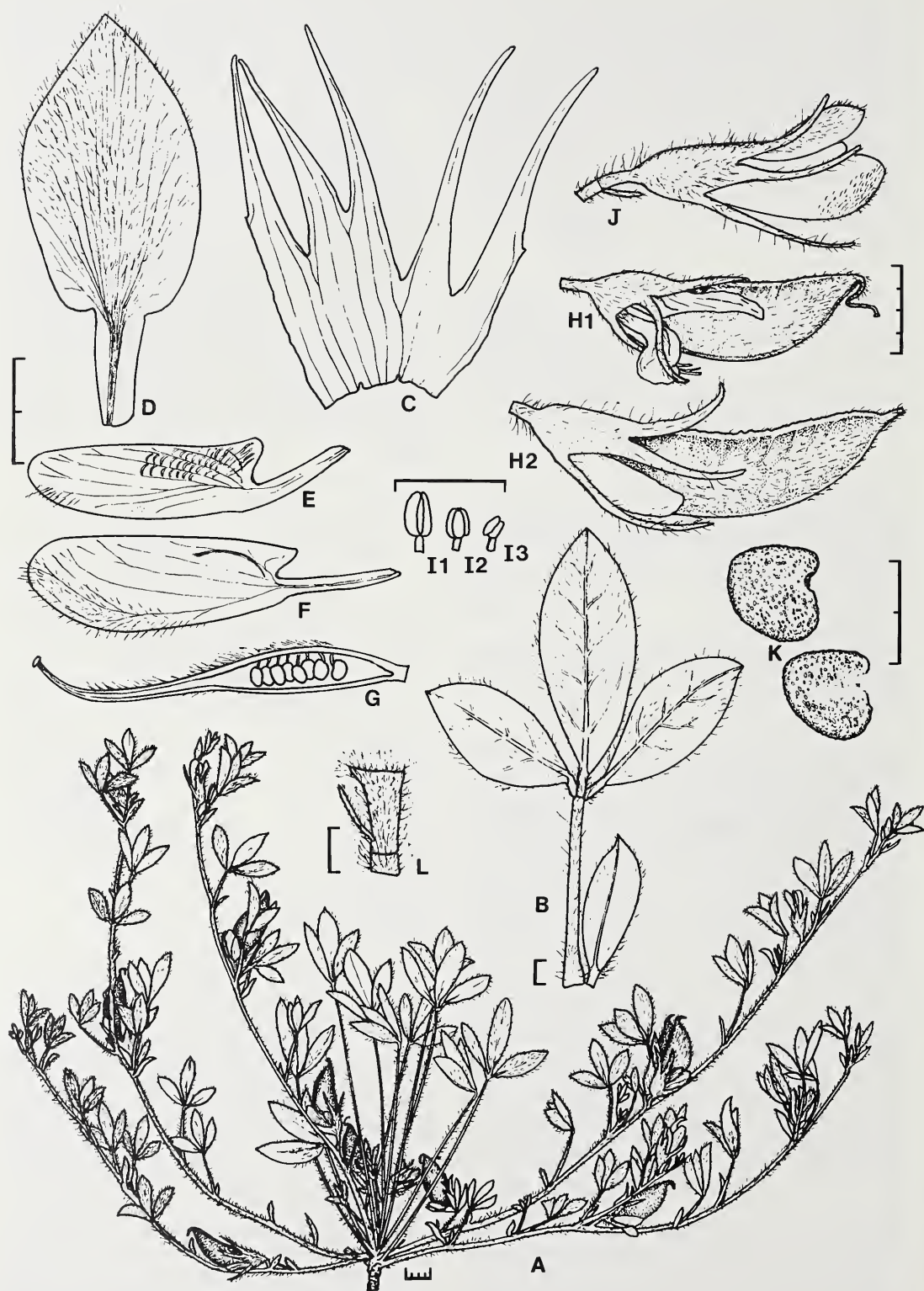


FIGURE 3.—*Lotononis acuticarpa*. A, habit; B, leaf in abaxial view; C, calyx opened out, upper lobes to the left showing the fusion of the lateral lobes (vestiture not shown); D, standard petal; E, wing petal; F, keel petal; G, pistil; H1 & H2, mature fruit in lateral view (note the size, shape and also the pointed, tapering apices). I1–I3, anthers: I1, basifixed anther; I2, carinal anther; I3, dorsifixed anther. J, flower in lateral view; K, seeds in lateral view, showing tuberculate surfaces; L, peduncle with pedicel and bract. All from Van Wyk 1815. Scales in mm.

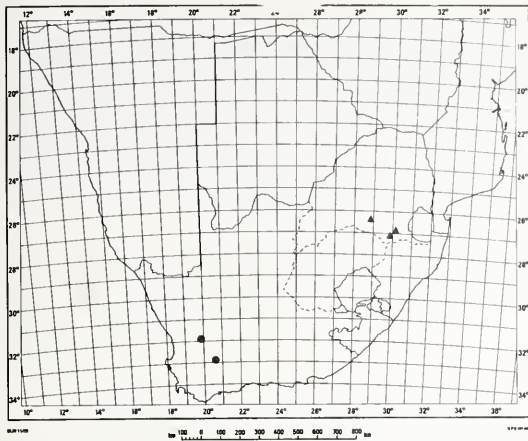


FIGURE 4. —The known geographical distribution of *Lotononis venosa*, ●; and *L. acuticarpa*, ▲.

CAPE. —3119 (Calvinia): $\pm 3,6$ km from the Farm Blomfontein to De Hoop (—DD), 13.09.1986, *Schutte 259* (JRAU). 3220 (Sutherland): De Hoop in Klein Roggeveld (—DC), 06.09.1986, *Oliver 8965* (PRE, holo.; STE, iso.).

***Lotononis acuticarpa* B-E. van Wyk, sp. nov.**, *L. calycinae* similis sed habitu foliisque minore, floribus valde minoribus angustioribus, praesertim forma magnitudineque fructus differt. Fructus calycem valde superantia (calycem aequantes in *L. calycina*), plani (non turgidi ut in *L. calycina*) et apices sunt acuti sursum curvati (non obtusi deorsum curvati ut in *L. calycina*). Etiam similis est *L. adpressae* N.E. Br. sed ab illa specie habitu minori annuo, superficie adaxiali glabro foliolorum et fructu valde longiori acutiori subfalcato differt.

TYPE. —Transvaal, 2628 (Johannesburg): Springs District, 5 km from Devon radar station to Leandra (—BD), 20.02.1986, *Van Wyk 1815* (PRE, holo.; JRAU, K, MO, NBG, iso.). Figure 3.

Small procumbent annual up to 0,1 m high and 0,2 m wide. *Branches* slender, spreading from a very short main axis; twigs sparsely pilose. *Leaves* digitately trifoliolate, sparsely pubescent, variable in size, those on the main axis with long and slender petioles, those of lateral twigs with the petiole 3–6(–8) mm long; leaflets oblanceolate to elliptic, (3–)5–10(–14) \times (1–)2–2,5(–3) mm, abaxially sparsely pubescent, adaxially glabrous. *Stipules* consistently present, single at each node, oblanceolate to elliptic, 2–4 mm long. *Inflorescences* leaf-opposed at each node, fasciculate, 1–3-flowered; peduncle very short or absent; bracts small, up to 2,5 mm long, often inserted slightly above the pedicel base; bracteoles absent. *Flowers* very small, narrow, 6–7 mm long, yellow; pedicel short, up to 2 mm long. *Calyx* almost as long as the corolla, with the lateral lobes on either side fused much higher up in pairs, sparsely pubescent; lobes long and slender. *Standard* oblong-ovate, 6–7 mm long; claw 1,5–2 mm long; lamina acute, densely pubescent on the dorsal surface. *Wing petals* narrowly oblong, slightly shorter than the keel, pubescent towards the rounded apex; sculpturing in 3–4 rows of transcostal lunae fading into a few transcostal lamellae

towards the auricle. *Keel petals* oblong, obtuse, auriculate and pocketed near the base, pubescent along the lower edge of the lamina. *Anthers* dimorphic, basifixed anthers more than 2 \times longer than the dorsifixed anthers, carinal anther intermediate in size. *Pistil* 5–6 mm long; ovary oblong, ± 3 mm long, densely pubescent; style short, almost straight. *Pods* oblong, compressed, slightly falcate, twice as long as the calyx, 8–12 \times 2–3,5 mm, gradually tapering to the acute apex, ± 6 -seeded, upper suture \pm smooth, indehiscent or tardily dehiscent, inconspicuously pubescent. *Seed* suborbicular in side view, up to 1,8 mm long; funicles up to 2 mm long; testa brown, often yellowish brown mottled with black, distinctly tuberculate (Figure 3). *Chromosome number*: $2n = 18!$

L. acuticarpa is similar to *L. calycina* (E. Mey.) Benth. but differs in the smaller habit and leaves, the much smaller and narrower flowers and particularly in the shape and size of the fruit. The fruit are much longer than the calyx (as long as the calyx in *L. calycina*), flat (not turgid as in *L. calycina*) and the apices are acute and curved upwards (not obtuse and curved downwards as in *L. calycina*). It is also similar to *L. adpressae* N. E. Br. but differs from this species in the smaller and annual habit, the glabrous adaxial surface of the leaflets and in the much longer, more acute and slightly falcate fruit.

It is remarkable that this distinct species has escaped the notice of plant collectors for so long. *L. acuticarpa* was only recently collected for the first time and is now known from three different localities in the south-eastern Transvaal (Figure 4). It appears to be restricted to well-drained stony soils and is locally abundant, at least at the type locality.

TRANSVAAL. —2628 (Johannesburg): Springs District, 5 km from Devon radar station to Leandra (—BD), 20.02.1986, *Van Wyk 1815* (PRE, holo.; JRAU, K, MO, NBG, iso.). 22.02.1987, *Van Wyk 2625* (M, NH, S, STE). 2630 (Carolina): Mbabane, Kalkoenkranz, Goedemoed Farm (—CC), 15.03.1987, *Turner 1468* (PRE). 2729 (Volksrust): Frankfort, Amersfoort, Bergvliet Farm (—BB), 01.04.1987, *Turner 1624* (PRE).

ACKNOWLEDGEMENTS

I thank the directors and staff of the cited herbaria for the loan of specimens. Dr H. F. Glen (Botanical Research Institute, Pretoria) kindly translated the diagnoses. The taxonomic study of *Lotononis* is a registered Ph. D. project at the University of Cape Town.

REFERENCES

- ARROYO, M.T.K. 1981. Breeding systems and pollination biology in Leguminosae. In R.M. Polhill & P.H. Raven, *Advances in legume systematics* 2: 723–769. Royal Botanic Gardens, Kew.
- BENTHAM, G. 1843. Enumeration of Leguminosae, indigenous to southern Asia, and central and southern Africa. *Hooker's London Journal of Botany* 2: 594–613.
- BYTH, D.E. 1964. Breeding system and chromosome number in *Lotononis bainesii* Baker. *Nature* 202: 830.
- DÜMMER, R.A. 1913. A synopsis of the species of *Lotononis*, Eckl. & Zeyh., and *Pleiospora* Harv. *Transactions of the Royal Society of South Africa* 3: 275–335.
- ERICKSON, E.H. 1975. Variability of floral characteristics influences honey bee visitation to soybean blossoms. *Crop Science* 15: 767–771.

- HANSON, C.H. & COPE, W.A. 1955. Reproduction in the cleistogamous flowers of ten perennial species of *Lespedeza*. *American Journal of Botany* 42: 624–627.
- HARMS, H. 1909. Über Kleistogamie bei der Gattung *Argyrolobium*. *Berichte der Deutschen Botanischen Gesellschaft* 27: 85–96.
- HARMS, H. 1917. Weitere Beobachtungen über Kleistogamie bei afrikanischen Arten der Gattung *Argyrolobium*. *Berichte der Deutschen Botanischen Gesellschaft* 35: 175–186.
- HARVEY, W.H. 1862. Leguminosae. In W.H. Harvey & O.W. Sonder, *Flora capensis* 2: 47–66. Hodges & Smith, Dublin.
- SCHUTTE, A.L. 1988. 'n Taksonomiese studie van die genus *Dichilus* DC. (*Fabaceae*–*Crotalariaeae*). M.Sc. thesis, Rand Afrikaans University, Johannesburg.
- UPHOF, J.C.Th. 1938. Cleistogamic flowers. *The Botanical Review* 4: 21–49.
- VAN WYK, B-E. 1990. Studies in the genus *Lotononis*. 12. Four new species of the *L. falcata* group, section *Leptis*. *Bothalia* 20: 9–16.
- WOJCIECHOWSKA, B. 1972. Pollination and fertilization in *Ornithopus* sp. *Genetica Polonica* 13: 37–52.

Studies in the genus *Riccia* (Marchantiales) from southern Africa. 15. *R. hirsuta* and *R. tomentosa*, sp. nov., two distinct species previously treated as one

O.H. VOLK* and S.M. PEROLD**

Keywords: Marchantiales, *Riccia hirsuta*, *R. tomentosa*, section *Pilifer*, section *Micantes*, section *Pannosae*, southern Africa, subgenus *Thallocarpus*, taxonomy, tetrad spores

ABSTRACT

The description of *Riccia hirsuta* (Volk & Perold 1986) is emended and new illustrations of the species are provided, as the original description and illustrations were based on two distinct, but rather similar species. Examination of newly collected material of *R. hirsuta*, showed it to belong to subgenus *Riccia*, section *Pilifer* (Volk 1983). Section *Micantes* (Volk & Perold 1986) of which this was the type species, is therefore transferred to section *Pilifer*. *R. tomentosa* Volk & Perold, sp. nov., described here, is at first glance somewhat similar to *R. hirsuta* in its habit, hence the earlier confusion in Volk & Perold (1986). It also resembles *R. hirsuta* in its dorsal covering of long hairs and in the triangular scales apically split into cellular strands. *R. tomentosa*, however, differs from *R. hirsuta* in the spongy (not compact) construction of the thallus and in the spores permanently united in tetrads (not single). It belongs to subgenus *Thallocarpus* and is the type species of the new section *Pannosae*.

UITTREKSEL

Riccia hirsuta (Volk & Perold 1986) word herbeskryf en herillustreer, aangesien die vroeëre beskrywing en illustrasies op twee verskillende, maar tog ietwat soortgelyke spesies gebaseer was. Die ondersoek van nuwe materiaal van *R. hirsuta*, het getoon dat dit tot subgenus *Riccia*, seksie *Pilifer* (Volk 1983) behoort. Seksie *Micantes* (Volk & Perold 1986) waarvan dit die tipe-spesie was, word derhalwe onder seksie *Pilifer* geplaas. *R. tomentosa* Volk & Perold, sp. nov., hier beskryf, is by die eerste aanblik taamlik soortgelyk aan *R. hirsuta* wat groeivorm betref, vandaar die vroeëre verwarring in Volk & Perold (1986). Dit toon ook ooreenkomst met *R. hirsuta* in die dorsale bedekking van lang hare en in die driehoekige skubbe wat apikaal in sellulêre stringe verdeel is. *R. tomentosa* verskil egter van *R. hirsuta* in die sponsrige (nie kompakte) bou van die thallus en in die spore wat permanent in tetrades verenig is (nie enkel nie). Dit behoort tot die subgenus *Thallocarpus* en is die tipe-spesie van die nuwe seksie *Pannosae*.

INTRODUCTION

When *R. hirsuta* Volk & Perold (1986), the figures of which are referred to below as 1986, was described, it was assumed that all five specimens then listed under this species, definitely belonged here. Among these specimens, only *Oliver 8040* had mature spores. Even though there were some indications that the material was not quite homogeneous, the possibility of another, rather similar species, existing in the same area seemed remote, and it was assumed that all material belonged to one species. During fieldwork by Perold in Namaqualand in September/October 1987 and August/September 1988 and by Oliver in July 1989, six new collections of densely hairy specimens were made, each one with distinctly papillose spores which on maturity remain in permanent, \pm globular tetrahedral tetrads. These collections belong to a new species, *R. tomentosa* (see below). Fresh gatherings of *R. hirsuta*, also with a dense dorsal hair covering but with single, reticulately ornamented spores were also made, thus providing more material for study.

Riccia hirsuta emend. Volk & Perold

Monoica (?), viridi-grisea, mediocris, perennis; frons usque ad 10 mm longa, 2–4 mm lata, duplo ad triplo latior

quam crassa, simplex vel furcata, obcuneata vel oblonga, apice breviter emarginata sparsimque sulcata, antice convexa, in sicco subplana ad concava, dense hirsuta ob pilos longos (inde nomen speciei), marginibus plus minus attenuatis; costa lata, crassa, subplana vel convexa, ad margines sensim excurrens. *Stratum aeriferum* canalibus aeriferis altis. *Squamae* grandes, marginem frondis superantes, imbricatae, hyalinae, deltatae, apicibus in filis liberis scissis, vel dentatis. *Sporae* triangulo-globulares, polares, brunneae, 115–125 μ m diametro, late alatae, margine subtiliter crenato, imperfecte reticulatae, granulatae; areolae in diametro sporarum 6–8, centrales majores. *Chromosomatum numerus* $n = 8$ (Bornefeld 1984).

Thallus monoicous (?), perennial, scattered, not in rosettes, dorsal surface hirsute with thick pelt of shiny hairs (Figure 2A), whitish along margins, greenish grey over centre; medium-sized to large (Figures 1A, C; 1986: 1A); branches simple or bifurcate, up to 10 mm long, 2.0–4.0 mm wide, 1.5–2.0 mm thick, i.e. about once to twice wider than thick; oblong, broadening towards truncate apex (Figure 2B); groove short, soon becoming flat; margins subacute; flanks sloping outwards in a short wing (Figure 1D), greyish green, occasionally with some reddish purple flecks; ventral surface slightly rounded to plane, pale green; when dry (Figure 1B), sides partly inflexed, dorsal surface grey, dusty from accumulation of sand grains trapped between hairs.

* Botanische Anstalten d. Univ. Würzburg D8700, Germany, BRD.

** National Botanical Institute, Private Bag X101, Pretoria 0001.

MS. received: 1989.02.20.

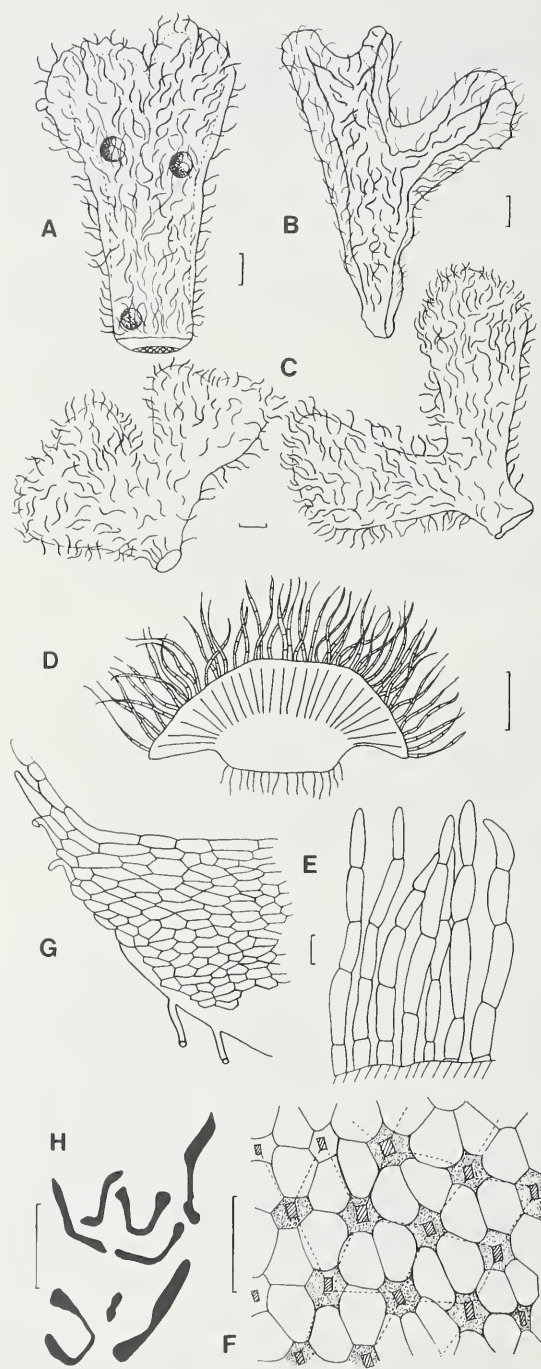


FIGURE 1.—*Riccia hirsuta*. Morphology and anatomy. A, old thallus with sporangia; B, dry thallus, margins inflexed; C, two young thalli from culture; D, transverse section through mature thallus; E, dorsal hair pillars in transverse section; F, horizontal section at level of stomata (hatched) and basal cells of hairs (hairs omitted) with air canals (stippled) and chlorenchyma also shown; G, scale; H, chromosomes. A, B, H, Oliver 8040 (Type); C, E–G, S.M. Perold 2182; D, Oliver 8038a. A–G by Volk; H by Bornefeld. Drawings by J. Kimpton. Scale bars on A–D = 1 mm; E–G = 100 µm; H = 1 µm.

Anatomy: dorsal covering of free-standing, water-repellent, hyaline, straight to bent, closely packed hair-like

cell pillars or filaments of nearly equal length, up to 1 200 µm long, occupying up to almost $\frac{1}{2}$ the thickness of the thallus (Figure 1D), consisting of four to six elongated, thin-walled cells (Figures 1E, 2C), up to $375 \times 40\text{--}100$ µm, gradually tapering to an often abruptly bent apex; air pores mostly 4-sided (Figure 2E), but varying from 3–6-sided, in contact with about four epithelial cells and leading to rather wide (40–80 µm), mostly 6-sided air canals (Figure 1F); assimilation tissue (chlorenchyma) about 300–500 µm thick, almost $\frac{1}{5}\text{--}\frac{1}{4}$, the thickness of thallus; storage tissue about 700 µm thick, consisting of polygonal cells, up to 50 µm wide; in older resting thalli, sometimes central core filled with fatty oil and starch (Figure 1986: 1C3); rhizoids arising from ventral epidermis and base of scales, hyaline, some smooth and others tuberculate, up to 25 µm wide. Scales partly extending above margin of thallus, overlapping apically, triangular (Figures 1G; 2F; 1986: 1E1–3), about 650 µm wide at base and up to 1 500 µm high, hyaline, occasionally with reddish purple cells at base; cells thin-walled, in body of scale up to $\pm 180 \times 50$ µm, oblong-hexagonal, apex dentate, or more usually cells elongated and separating into a few short, variously bent or twisted filaments (Figures 1G; 2F; 1986: 1F1–4). *Antheridia* flask-shaped, with much elevated necks (Figures 2D; 1986: 1G), hidden by dorsal pillars. *Archegonia* with purple necks. *Sporangia* arranged across width of thallus, up to 700 µm wide, overlying tissue often tinged with purple, each containing about 650 spores. *Spores* triangular-globular, polar, deep dull brown to nearly black, semitransparent to opaque, (95–)115–125 (–130) µm in diameter, with wing about 10 µm wide, granular, slightly undulating, margin crenulate to somewhat eroded, at angles with a pore or notched (Figures 2H, I; 1986: 3F); distal face reticulate, with 3–5 (–6) large central areolae, 25–38 µm wide, completely or incompletely subdivided into smaller areolae, about 12,5 µm wide, often with a papilla in the middle (Figure 2H, I), occasionally areolae equally wide and then 8–10 across diameter; central ridges thick and high, outer ridges thinner and lower, sometimes extending partly on to wing (Figure 1986: 3C, D); proximal face with triradiate mark distinct, but poorly delineated, each facet irregularly and rarely completely reticulate (Figures 2G; 1986: 3A, B). *Chromosome number* $n = 8$ (Bornefeld in Volk & Perold 1986) (Figure 1H).

R. hirsuta is extremely rare and only known from the plateau N of Leliefontein (Figure 3) (altitude $\pm 1\,500$ m above sea level), in a winter rainfall area with less than 200 mm rain per annum. It grows in association with other *Riccia* species, e.g. *R. limbata* Bisch., *R. bullosa* Link ex Lindenb., *R. cupulifera* A.V. Duthie and *R. schelpi* Volk & Perold, on clayey soil, at a seepage area or in seasonally damp sandy places between small shrublets and Restionaceae.

R. hirsuta is distinguished from other species in section *Pilifer* by the very tall, shiny dorsal cell pillars and by the triangular scales, apically split into filamentous, short, loose, cellular strands.

SPECIMENS EXAMINED

CAPE.—3018 (Kamiesberg): Kamiesberg, lower slopes east of Rooiberg, damp ground between and under renoster bushes (–AC), Oliver 7240 p.p. (F; PRE); Kamiesberg plateau, north of Leliefontein, towards

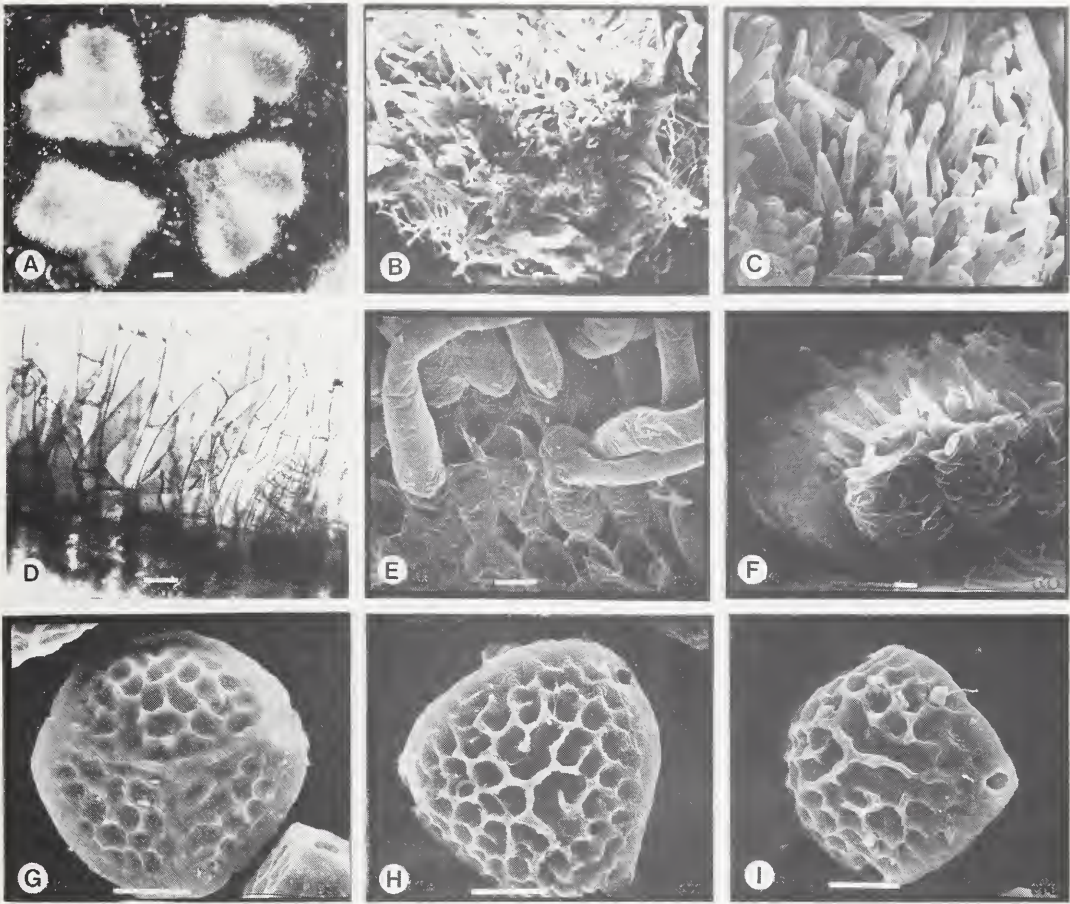


FIGURE 2. — *Riccia hirsuta*. Morphology and anatomy, spore ornamentation. A, two young thalli; B, apex of thallus from above, densely hairy; C, apices of hair pillars; D, part of transverse section, showing bases of hairs and young antheridial neck; E, two rows of 4-sided air pores, from above, hairs partly removed; F, thallus flank with four scales, two central ones with appendages; G, proximal face of spore; H, distal face; I, side view of distal face. A, B, D, *Oliver 8040* (Type); C, E–I, *S.M. Perold 2101*. A, D, LM micrographs by Volk; B, C, E–I, SEM micrographs by Perold. Scale bars on A = 1 mm; B–F = 100 μ m; G–I = 50 μ m.

Draaiklip, on sandy, periodically moist soil, associated with other *Riccia* species and Restionaceae, (–AC), *Oliver 8038(a)*, 8040 (PRE, holo.); on road between Kamieskroon and Leliefontein, 5 km north of Leliefontein, at seepage area (–AC), *S.M. Perold 2099–2101*; 2182 (PRE).

Riccia tomentosa Volk & Perold, sp. nov.

Dioica (?), pallida, magna, perennis; frondes ad 18 mm longae, ad 5 mm latae, ad 4 mm crassae, late liguliformae,

REJECTION OF SECTION MICANTES VOLK & PEROLD

Section *Pilifer* Volk in Mitteilungen aus der Botanischen Staatssammlung, München 19: 453 (1983). Type species: *Riccia albomarginata* Bisch. ex Krauss.*

Section *Micantes* Volk & Perold in Bothalia 16: 187 (1986). Type species: *Riccia hirsuta* Volk & Perold.

R. hirsuta, as here emended, agrees in its anatomy and spores with members of the section *Pilifer* and is therefore placed under that section. Section *Micantes*, of which it previously was the type species (Volk & Perold 1986), is now rejected.

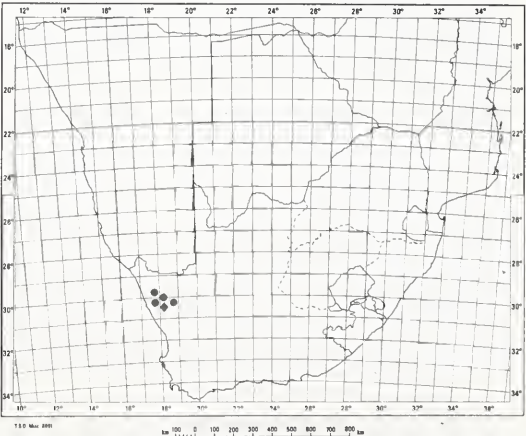


FIGURE 3. — Distribution map of *Riccia hirsuta*, ♦; and *R. tomentosa*, ●, in southern Africa.

* See Perold (1990) [one of the present authors (S.M.P.) is of the opinion that the name *R. albomarginata* has been misapplied since Sim (1926)].

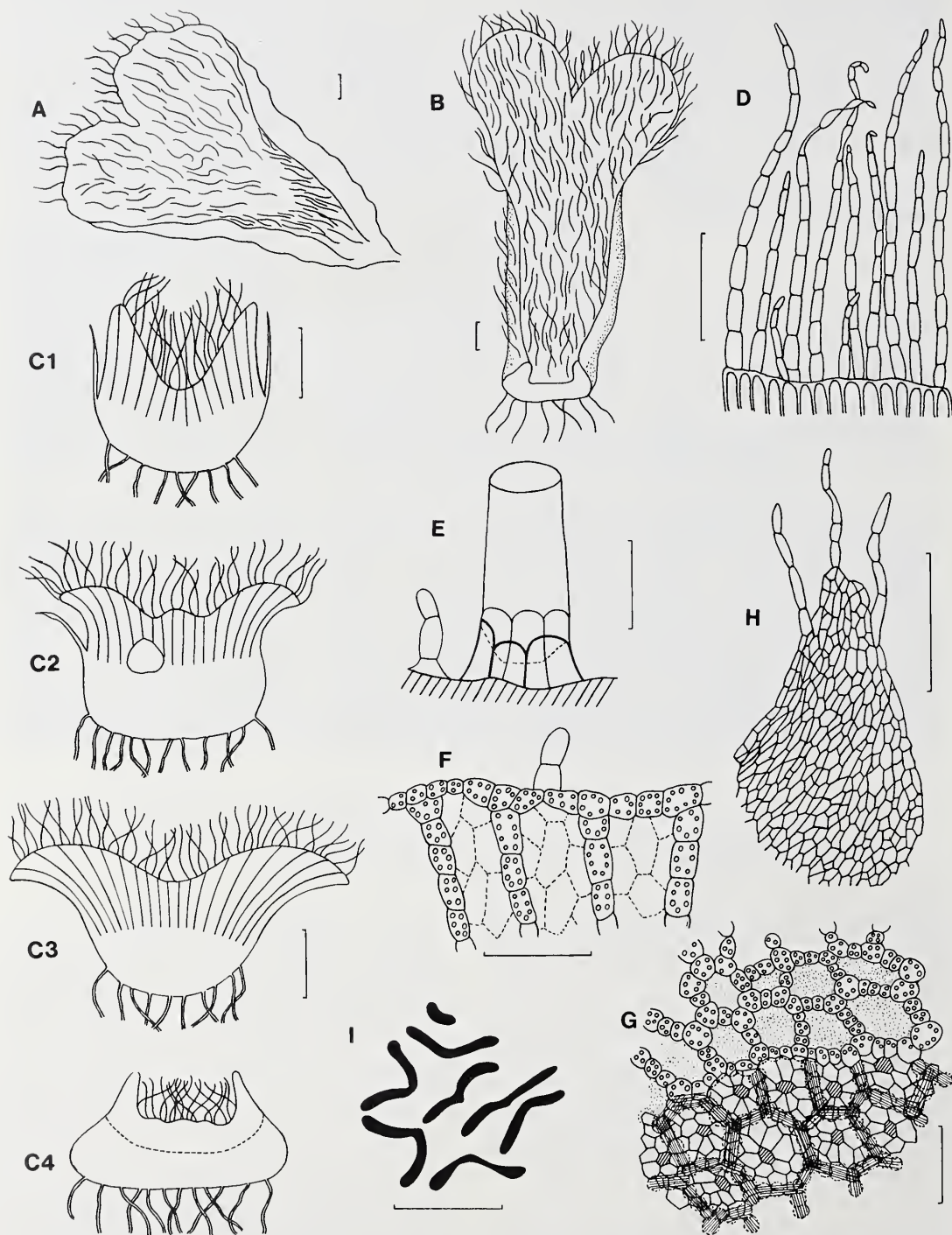


FIGURE 4.—*Riccia tomentosa*. Morphology and anatomy. A, mature thallus; B, older thallus, flanks inflexed towards base; C1–4 transverse sections through thallus branches (C1, near apex; C2, C3 at different distances along length of B, C4 through oldest dying part); D, variable length of filaments on dorsal surface; E, hair base with supporting cells; F, lacunae and epidermis; G, horizontal section near dorsal surface viewed from below, hence hairs not visible: bottom right, epidermis with stomata (hatched); above, chlorenchyma with lacunae (stippled); H, scale with filaments at apex; I, chromosomes. A, B, C2–4, D–F, H, *S.M. Perold & Crosby 2157*; C1, *Schelte 7784*; G, *S.M. Perold 1495*; I, *Le Roux & Fourie PRE-CH4494*. A–H by Volk; I by Bornefeld. Drawings by J. Kimpton, after Volk. Scale bars on A–C = 1 mm; D, H = 500 μ m; E–G = 100 μ m; I = 1 μ m.

concavae, simplices vel furcatae, subgregariae vel singulares; pagina superiora in sicco tomentosa (inde nomen) pilis longitudine inaequali usque ad 2 700 μm longis usque ad 14 cellulis compositis vestita; costa semilunata vel subplana in alas breves excurrentes, alae in sicco erectae; stomata distantes, aliquot cellulis circumdata; lacunae aeriferae ad 280 μm dilatatae; squamae triangulares, ad 1 500 μm longae, apicem versus sparsim filamentosae. *Sporae* in tetradibus tetraedrica globularibus permanentiter conjunctae, 100–130–145 μm diametro, sulphureae vel fuscatae, subglobosae, dense papillosae, semiopacae vel opacae. *Chromosomatum numerus* $n = 8$ (Bornefeld 1989).

TYPE.—Cape Province, 3018 (Kamiesberg): Pedroskloof, on road to Rooifontein, 2 km beyond Willem Stone Bridge, on sandy soil overlying clay (—AA), 1987.09.24, *S.M. Perold* 1495 (PRE, holo.), associated with other *Riccia* spp. and *Bryum* spp.

Thallus dioicous (?), perennial, scattered or in crowded patches, dorsal surface 'shaggy'-haired or tomentose (Figure 4A, B; 1986: 1B, 2A), silvery to dusty grey, often with trapped sand particles between hairs; branches large, up to 18 mm long, simple or bifurcate, segments $\pm 12 \times 2-4-5$ mm, narrower toward base (Figure 4C4), oblong to ovate-oblong, apex slightly narrowed, shortly emarginate, groove short and wide, middle part concave, $\pm 3-4$ mm thick, i.e. almost as wide as thick in section (Figure 4C1), margins raised, obtuse, shortly winged (Figures 4C2, C3; 5B), flanks sloping steeply upward and outward, lower parts occasionally coloured red; ventral face rounded to plane, pale green; when dry, whitish, wide, dorsally deeply concave in centre, wings erect or scarcely inflexed to somewhat reflexed.

Anatomy: dorsal surface covered by free, straight or bent hair-like filaments or pillars (Figures 4D; 5D; 1986: 1D),

up to 2 700 μm long, tapering upwards from a broad base and composed of up to 14 short or elongated thin-walled, hyaline cells of variable length and thickness (Figure 5E), often supported by slightly raised epidermal cells (Figure 4E, 1986: 2D); air pores circumscribed by several (5–7) radially arranged, wedge-shaped cells (Figures 4G; 5F; 1986: 2G, H); assimilation tissue (chlorenchyma) ± 500 μm thick, $1/8-1/6$ the thickness of thallus, with sloping, elongated, polygonal air chambers or lacunae up to 280 μm wide (Figures 4F; 1986: 2E), 37–62(–112) μm wide, longest and widest in wings (Figure 5C3) surrounded by isodiametric cells in plates, one cell thick and up to 20 cells high; storage tissue $\pm 500-600$ μm thick, $1/8-1/6$ the thickness of thallus, cells angular, up to 50 μm wide, with small spaces between. Rhizoids arising ventrally and from base of scales, forming a thick mat, some smooth, mostly tuberculate, 12–25 μm wide. *Scales* triangular, large, up to 1 500 μm long and base 1 250 μm wide, hyaline, often red at base, apically with filaments up to 1 000 μm long (Figure 4H; 1986: 2F), cells in body of scale 5-sided, walls straight to slightly sinuous, up to $112 \times 25-42$ μm , smaller at base, 62×40 μm ; at one side of scale, a row of rectangular cells, up to 180×40 μm . *Antheridia* and *archegonia* difficult to see, as obscured by dense dorsal hairs. *Sporangia* bulging dorsally, ± 800 μm wide, each containing ± 300 spore tetrads. *Spores* thick-walled, permanently united in tetrads (Figure 6A, B, E, F), 116–131–145 μm in diameter, pale yellow to ferruginous brown, thickly beset with papillae or verruculae, 3–5 μm wide and projecting as much, obtuse or truncate, arising from nodes of scarcely visible (Figure 6C), to obvious reticulum (Figure 6D). *Chromosome number* $n = 8$ (Bornefeld 1989).

R. tomentosa is endemic and rare, as it has only been found at a few localities in Namaqualand (Figure 3), at altitudes of 1 000–1 200 m above sea level, with winter

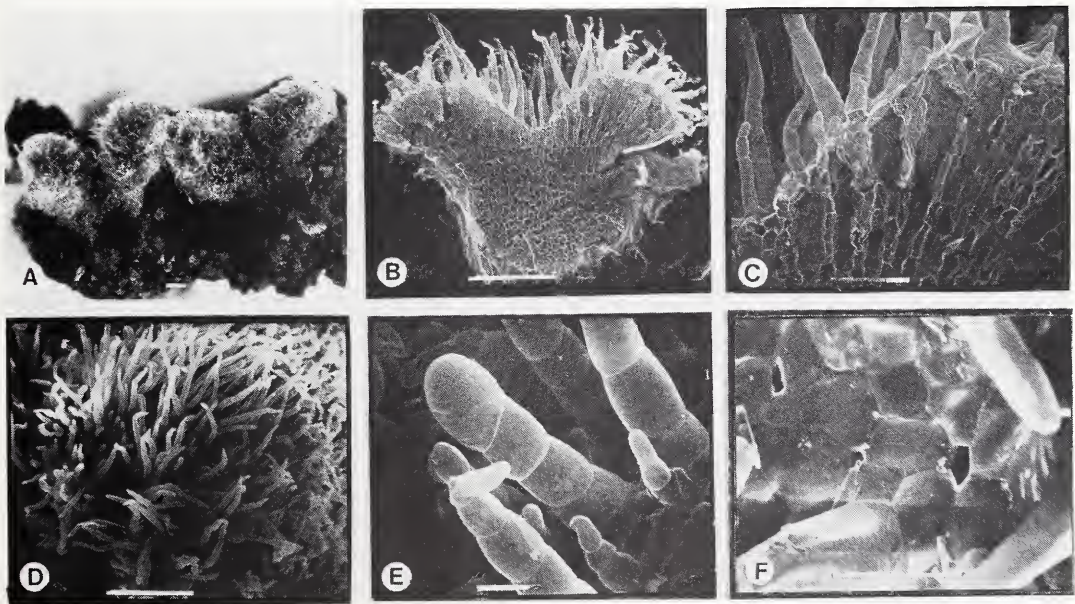


FIGURE 5.—*Riccia tomentosa*. Morphology and anatomy. A, two young thalli; B, transverse section through thallus branch; C, transverse section through wing with wide lacunae; D, hairs from above; E, variable sizes of dorsal hairs; F, epidermis with air pores. A, *S.M. Perold & Crosby* 2157; B–D, *S.M. Perold* 1556; E, *S.M. Perold* 1495; F, *Le Roux & Fourie* PRE-CH4494. A, by A. Romanowski; B–E, SEM micrographs by *S.M. Perold*. Scale bars on A, B, D = 1 mm; C, E, F = 100 μm .

rainfall of less than 200 mm per annum. It grows on reddish brown, sandy soil, overlying clay, at pH values 5,6; 6,6; 6,8 and 7,5, in open areas and in association with *Bryum argenteum* Hedw. Its distribution is sympatric with that of *R. hirsuta*.

R. tomentosa is dorsally tomentose, hence the specific epithet, and differs from other southern African *Riccia* species, e.g. *R. hirsuta* (Table 1), by the unique hair-like outgrowths from many of the epidermal (not epithelial) cells and by the papillose to verruculose tetrad spores. It shares large triangular scales, apically splitting into filamentous cellular strands with *R. hirsuta*.

SPECIMENS EXAMINED

CAPE.—2917 (Springbok): Hester Malan Res., Carolusberg N, at gate on western boundary (—DB), *Le Roux & Fourie PRE-CH4494* (PRE); *Schelpé 7784* (BOL, PC, PRE). 3017 (Hondeklipbaai): Arkoep area, 15 km N of Kamieskroon, road towards Brakwater, sandy clay flats, open ground (—BB), *Oliver 9196, 9197* (PRE). 3018 (Kamiesberg): 18 km NE of Kamieskroon on road to Rooifontein, at rock outcrop, on soil (—AA), *Perold & Reid 1462* (PRE); 4 km on road to Rooifontein, after turnoff from Kamieskroon/Leliefontein road, sandy soil (—AA), *Perold & Crosby 2157, 2158* (PRE); Pedroskloof, on road to Rooifontein, 2 km beyond Willem Stone Bridge (—AA), *S.M. Perold 1495* (PRE, holo.); 29 km SE from Platbakkies on road to Kliprand, Farm Banke, rock outcrops, sandy soil (—BC), *S.M. Perold 1556* (PRE). *Vogel C5446* (MJG), Nuwefontein, Hondeklipbaai, may belong here, but its identity is uncertain as it is sterile).

Among the species of *Riccia* presently known, *R. tomentosa* occupies a unique position as it has both primitive and derived characters. The spores of subgenus *Thallocarpus* which remain in tetrads, are regarded as primitive (Jovet-Ast 1987), as are also the 'loose' construction of the assimilation tissue with wide lacunae, and the chlorophyllose epidermis which is pierced by air pores (stomata) that are circumscribed and separated by a ring of cells. Regarded as derived characters are the hairy

covering of the dorsal surface of the thallus (similar to that in the section *Pilifer*, subgenus *Riccia*) and the raised basal cells of the larger hairs.

SECTION PANNOSAE

Pannosae *Perold*, sect. nov., subgen. *Thallocarpus* (Lindb.) Jovet-Ast. Sporae permanentiter conjunctae in tetradibus; thallus dorsaliter pannosus ob pilos longos (inde nomen).

Ripe spores permanently united in tetrads; thallus dorsally felt-like (pannosus) because of long hairs.

TYPE.—*R. tomentosa* Volk & Perold.

Pannosae is a new section of subgenus *Thallocarpus*. *R. tomentosa* is the type species and only known species of this new section, which is characterized by spores permanently joined together in tetrads, as in other members of subgenus *Thallocarpus* (Lindb.) Jovet-Ast, but differs from all hitherto known species of this subgenus by a thick felt-like (Lat. *pannosus*) covering of very long, multicellular hairs.

CORRECTION OF PUBLISHED ILLUSTRATIONS

The existence of two similar-looking species, in the same area, regrettably gave rise to mistakes not only in the naming of the specimens, but also in the illustrations (Volk & Perold 1986). Specimens from both species were used for Figures 1 and 2 (pp. 188 & 189). For Figures 1B, H and 2A–H, *Le Roux & Fourie PRE-CH4494* was used and for Figure 1D, *Schelpé 7784*; these two specimens were collected from the same population, and are *R. tomentosa*; firstly, because the air pores are distant and secondly, because the spores from *Schelpé 7784*, though immature and diseased, nevertheless suggest that the ornamentation

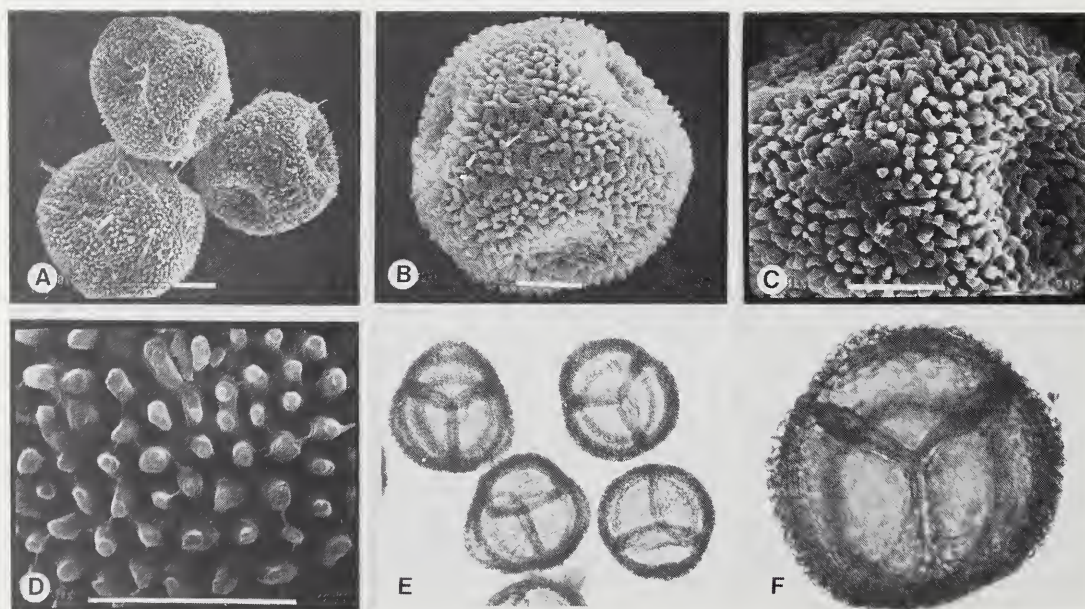


FIGURE 6.—*Riccia tomentosa*. Spores. A, three tetrads; B, one tetrad; C, join mostly hidden by tubercles; D, reticulum between tubercles; E, F, tetrads. A, E, *S.M. Perold 1556*; B, C, F, *S.M. Perold 1495*; D, *S.M. Perold & Crosby 2157*. A–D, SEM micrographs by S.M. Perold; E, F, LM micrographs by Volk. Scale bars on A–D = 50 μ m; width of tetrads on E, F = \pm 125 μ m.

TABLE 1.—Differences between *R. hirsuta* and *R. tomentosa*

<i>R. hirsuta</i>	<i>R. tomentosa</i>
1. spores single; ornamentation reticulate	spores in tetrads; ornamentation papillate
2. hairs of dorsal covering crowded, ± equally long	dorsal hairs spaced, of variable length
3. base of hairs without supporting cells	base of some hairs with raised supporting cells
4. epithelium with unspecialized air pores closely spaced, each epithelial cell in contact with several air spaces	epidermis with well-spaced stomata, radially circumscribed by 5–7 wedge-shaped cells; some cells without contact with air pores
5. air canals short, fairly wide	air chambers long, wide, sloping
6. thallus medium-sized, dorsally flat to ± convex	thallus large, concave dorsally
7. found in exposed locality at seepage, or in light shade at area under shrublets	found in fully exposed localities in sandy, drier areas

could be papillate to tuberculate. Unfortunately, these clues were subsequently ignored, when examining *Oliver 8040* (the type specimen of *R. hirsuta* Volk & Perold emend.), which has very crowded dorsal hairs and mature, triangular-globular spores with ± incomplete reticulate ornamentation on both faces, as illustrated in Figure 3 p. 190 (Volk & Perold 1986).

The captions should accordingly be corrected as follows: for Figure 1, *R. hirsuta* A, C1–3, E1–3, F1–4, G (*Oliver 8040, 8038b*); *R. tomentosa* B, H (*Le Roux & Fourie PRE-CH4494*); D, *Schelppe 7784*; and for Figure 2, *R. tomentosa* (not *R. hirsuta*) *Le Roux & Fourie PRE-CH4494*.

ACKNOWLEDGEMENTS

The authors wish to thank Dr habil. T. Bornefeld, Am Reele 1, D-8706, Höchberg, W Germany for the chromosome counts and figures and the Curator of BOL, University of Cape Town for the loan of the late Prof. E.A. Schelpe's specimen. Sincere thanks to Dr E.O. Campbell, Massey University, New Zealand and Dr E.W. Jones, Oxford, for reading the manuscript and for their valuable criticism.

REFERENCES

BORNEFELD, T. 1989. The *Riccia* species of S and SW Africa. Chromosome numbers and composition of the chromosome sets. *Nova Hedwigia* 48: 371–382.

JOVET-AST, S. 1975. Précisions sur les caractères de deux *Riccia* du sous-genre *Thallocarpus*. *Revue Bryologique et Lichénologique* 41: 449–456.

JOVET-AST, S. 1987. Vers une classification phylogénétique des espèces du genre *Riccia*. *The Bryologist* 90: 321–330.

KRAUSS, F. 1846. Pflanzen des Cap- und Natal-Landes, gesammelt von Dr. Ferdinand Krauss. *Flora* 29: 135, 136.

PEROLD, S.M. 1989. Spore-wall ornamentation as an aid in identifying the southern African species of *Riccia* (Hepaticae). *Journal of the Hattori Botanical Laboratory* 67: 109–201.

PEROLD, S.M. 1990. Studies in the genus *Riccia* (Marchantiales) from southern Africa. 16. *R. albomarginata* and *R. simii* sp. nov. *Bothalia* 20: 31–39.

SIM, T.R. 1926. The bryophyta of South Africa. *Transactions of the Royal Society of South Africa* 15: 1–475.

VAN ZINDEREN BAKKER, E.M. 1956. *South African pollen grains and spores*. Part II: 61–132. Balkema, Amsterdam.

VOLK, O.H. 1981. Beiträge zur Kenntnis der Lebermoose (Hepaticae) aus Südwestafrika (Namibia). II. *Mitteilungen aus der Botanischen Staatssammlung, München* 17: 245–252.

VOLK, O.H. 1983. Vorschlag für eine Neugliederung der Gattung *Riccia* L. *Mitteilungen aus der Botanischen Staatssammlung, München* 19: 453–465.

VOLK, O.H. 1988. *R. crenatodentata* (Marchantiales) sp. nov. aus Arabien. Studien über Bryophyten aus Arabien II. *Nova Hedwigia* 46: 27–35.

VOLK, O.H. & PEROLD, S.M. 1986. Studies in the genus *Riccia* (Marchantiales) from southern Africa. 6. *R. hirsuta*, a new species in a new section. *Bothalia* 16: 187–191.

Studies in the genus *Riccia* (Marchantiales) from southern Africa. 16. *R. albomarginata* and *R. simii*, sp. nov.

S.M. PEROLD*

Keywords: Marchantiales, *Riccia albomarginata*, *R. concava*, *R. simii*, sp. nov., *Riccia* section *Pilifer*, southern Africa, taxonomy

ABSTRACT

A description of *Riccia albomarginata* Bisch. ex Krauss, augmented with the aid of new collections which most closely match the relevant fragments of the type material, is presented. The type collection comprises two species. The fragments that I consider to be in closest agreement with Krauss's protologue are selected as lectotype. As far as could be established the rest of the type material is probably referable to *R. concava* Bisch. As previously mentioned by Perold (1989b), Sim (1926) and subsequent authors had applied the name '*R. albomarginata*' to a different taxon. This taxon, *R. albomarginata* auct. non Bisch., is now described and illustrated as *R. simii*, sp. nov. Its distribution and ecology are also noted.

UITTREKSEL

'n Beskrywing van *Riccia albomarginata* Bisch. ex Krauss, uitgebrei met behulp van nuwe versamelings wat die nouste met die toepaslike fragmente van die tipeversameling ooreenkom, word gegee. Die tipeversameling bestaan uit twee spesies. Die fragment wat na my mening die nouste met Krauss se protoloog ooreenstem, word as lektotipe aangewys. Sover vasgestel kon word, verteenwoordig die res van die tipemateriaal waarskynlik *R. concava* Bisch. Soos reeds vermeld deur Perold (1989b), het Sim (1926) en latere outeurs die naam '*R. albomarginata*' op 'n ander takson toegepas. Hierdie takson, *R. albomarginata* auct. non Bisch., word nou beskryf en geïllustreer as *R. simii*, sp. nov. en die verspreiding en ekologie word ook vermeld.

INTRODUCTION

The collections discussed below are in a poor to very poor condition. The relevant descriptions by early authors are very incomplete and lack reference to important diagnostic features such as the free-standing dorsal cell pillars. Furthermore, no illustrations were provided by these authors. In addition, species of section *Pilifer*, to which the species under discussion belong, are often very difficult to distinguish, particularly in a dry state, as the dorsal pillars remain collapsed and cannot be reconstituted to examine their shape and size. Nevertheless, after a thorough investigation of all available evidence and on the basis of expertise gained through the study of numerous specimens of species belonging to the section *Pilifer*, I have arrived at the following conclusions: the collection of *R. albomarginata*, annotated by Bischoff and held at BM (presumably Krauss's collection) is decidedly a mixed collection; the parts *alpha* and *beta* referred to by Bischoff on the specimen label (or varieties *alpha* and *beta* according to Gottsche *et al.* 1846) belong to different species, and var. *beta* is probably referable to *R. concava* Bisch. ex Krauss; *R. albomarginata* has no cilia along the thallus margins and had been incorrectly classified by Gottsche *et al.* under their section *Ciliatae*.

***Riccia albomarginata* Bisch. ex Krauss** in Flora 29: 135 (March 1846); Gottsche, Lindenberg et Nees ab Esenbeck: 604 (Oct. 1846) p.p. as to var. *alpha*; Stephani: 329 (1898) (he did not see the type collection).

TYPE.—Cape, In Promontorio Bonae Spei, Krauss Julio 1838 (BM!), lecto. here designated: the specimen in the middle of the herbarium sheet).

Thallus monoicous (?), perennial, in crowded gregarious patches, in partial rosettes or scattered, olivaceous green to green when actively growing, somewhat velvety, with hyaline scales extending above thallus margins (Figures 1A; 2D); rather small (Figure 2A), branches once to several times symmetrically or asymmetrically furcate, medium divergent, 5–7 mm long, terminal segments 1–3 mm long (Figure 2C), 0.7–1.8 mm wide and 0.6–1.1 mm thick, i.e. scarcely wider to nearly twice wider than thick in cross section (Figure 1E); lingulate to oblong or linear, apex rounded, emarginate, deeply grooved apically, soon widely concave dorsally (Figure 2B); margins subacute, flanks steeply rising, brown, occasionally with some purple colouring, distally covered by fragile, hyaline scales, basally often denuded of scales; ventral face gently rounded, green to brown; when dry (Figure 1B), dorsally concave, greenish white to light brown, scurfy or streaked with thin white threads of collapsed epithelial cell pillars, margins proximally incurved, undulating, with crisp, white or hyaline scales extending above parchment-like, brown flanks; distally sometimes tightly inflexed with scales meeting and clasped together along midline.

Anatomy of thallus: dorsal epithelium (Figures 1C; 2E) consisting of 3–4(–5) elongated cells in free-standing, fragile, hyaline pillars, ± 130 –200(–230) μm high, apical cell conical, narrowing toward tip, or of uniform width, sometimes bent, with apex rounded, 45 – 65×20 – $30 \mu\text{m}$, second and third cells 42 – 60×32 – $37 \mu\text{m}$, basal cell(s) 25 – 37×30 – $40 \mu\text{m}$; from above, pillars quite densely crowded together, fine and delicate, proximally collapsed, air pores mostly obscured, small, 4–5-sided (Figure 1D); assimilation tissue ± 250 – $350 \mu\text{m}$ thick in section, $\pm \frac{1}{3}$ the thickness of thallus and consisting of vertical columns of 7 or 8 isodiametric to short-rectangular cells, 32 – $47 \times 32 \mu\text{m}$, enclosing narrow air canals; storage

* National Botanical Institute, Private Bag X101, Pretoria 0001.
MS: received 1989.02.20.

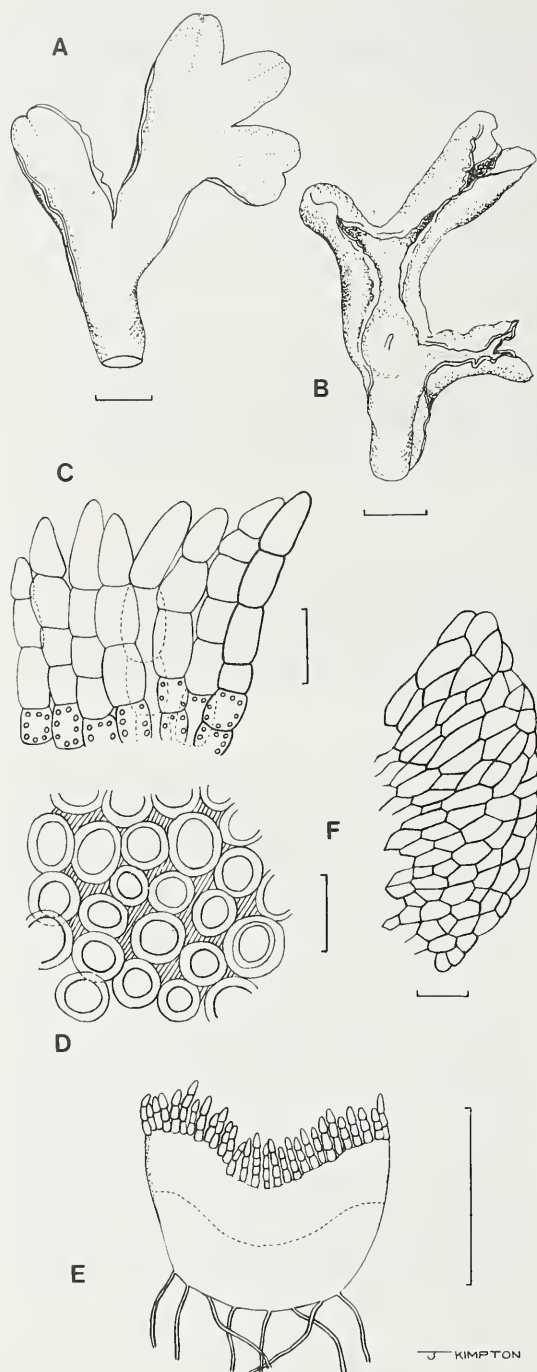


FIGURE 1.—*Riccia albomarginata*. Morphology and anatomy. A, thallus wet; B, thallus dry; C, transverse section through dorsal cell pillars at margin and scale; D, air pores from above; E, transverse section through thallus; F, scale. A, C, E, S.M. Perold 1979; B, S.M. Perold 2118; C, D, S.M. Perold 538; F, S.M. Perold 2031 p.p. Drawings by J. Kimpton. Scale bar on A, B, E = 1 mm; C, D = 50 μ m; F = 100 μ m.

tissue ± 300 μ m thick, occupying ventral part of thallus, cells rounded, ± 37 μ m wide; rhizoids arising from ventral epidermal cells and from base of scales, ± 25 μ m wide, some smooth, others tuberculate. Scales (Figures 1F; 2F)

rounded, imbricate, hyaline, fragile, extending up to ± 150 μ m above thallus margins, $700-800 \times 400$ μ m, cells in body of scales hexagonal, $60-80(-100) \times 40$ μ m, smaller at edge, cell walls straight, sometimes stained yellowish, base occasionally with a little purple colouring; basally scales absent. *Antheridia* numerous. *Archegonia* with purple necks. *Sporangia* along length of branches, single or occasionally in pairs, bulging dorsally and each containing ± 300 spores. *Spores* (75–)80–95(–105) μ m in diameter, triangular-globular, polar, brown to dark brown, semi-transparent to opaque, with wing 5–7 μ m wide, wider at perforated angles, margin \pm smooth to faintly crenulate; ornamentation reticulate and somewhat similar, to rather dissimilar on the two faces, with ± 14 irregular areolae across diameter of distal face (Figure 3B), complete or incomplete, up to 7 μ m wide, walls thick, slightly raised at nodes, otherwise smooth, convoluted (Figure 3C) or anastomosing into wide ridges that radiate outwards from centre (Figure 3E); proximal face with triradiate mark poorly to well defined (Figure 3A); $\pm 30-35$ small, completely or incompletely separated areolae on each facet, walls thick, convoluted, smooth, but raised at nodes (Figure 3D).

The above description and illustrations are based on S.M. Perold 538 p.p., 1930, 1979 and 2118.

As can be seen from Figure 3B, C, E, the spore ornamentation in *R. albomarginata* is quite variable, ranging from smallish areolae and a few thick radiating ridges, to mostly very thick, prominent ridges. On the whole, the ornamentation is not markedly different from that of *R. concava* (Perold 1989) or from the Zeyher collection of *R. albomarginata* (see below) (the part provisionally referred by me to var. *beta*), and the spores of these taxa would only be distinguished with difficulty by conventional light microscopical examination.

R. albomarginata has no outstanding vegetative characters by which it can be readily recognized; however, it is generally rather smaller than most other species in section *Pilifer*. In the dry state, it can frequently be distinguished by the light brown colouring of the dorsal face and the incurved flanks, fringed with hyaline or crisp, white scales that contrast strongly with the brown flanks, to which, it is thought, the specific epithet refers. Stephani (1898) described the scales as being prominent. Later authors, such as Sim, apparently assumed that the word 'prominent' also meant 'large' and therefore erroneously concluded that *R. albomarginata* is a species with large scales. In some cultured specimens, the brown colouration of the thalli and pale yellowish stain of the scale cell walls are persistent, even after a year. Sometimes tarry smudges are found at the flanks, as was also noticed in the var. *alpha* part of the Krauss specimen. It is doubtful whether this is the result of algal or fungal infestation.

R. albomarginata generally grows on rather coarse, gravelly soil, overlying granitic or sandstone outcrops, at altitudes between 200 and 1300 m above sea level, and receiving less than 200 to 400 mm of mostly winter rain per annum. It is often found in association with other *Riccia* species, e.g. *R. nigrella* DC. (which is rather smaller and much darker brown dorsally) and with *R. concava* Bisch., as well as with moss species, e.g. *Barbula crinita* Schultz, *Bryum* spp. and *Brachymenium* spp. It is

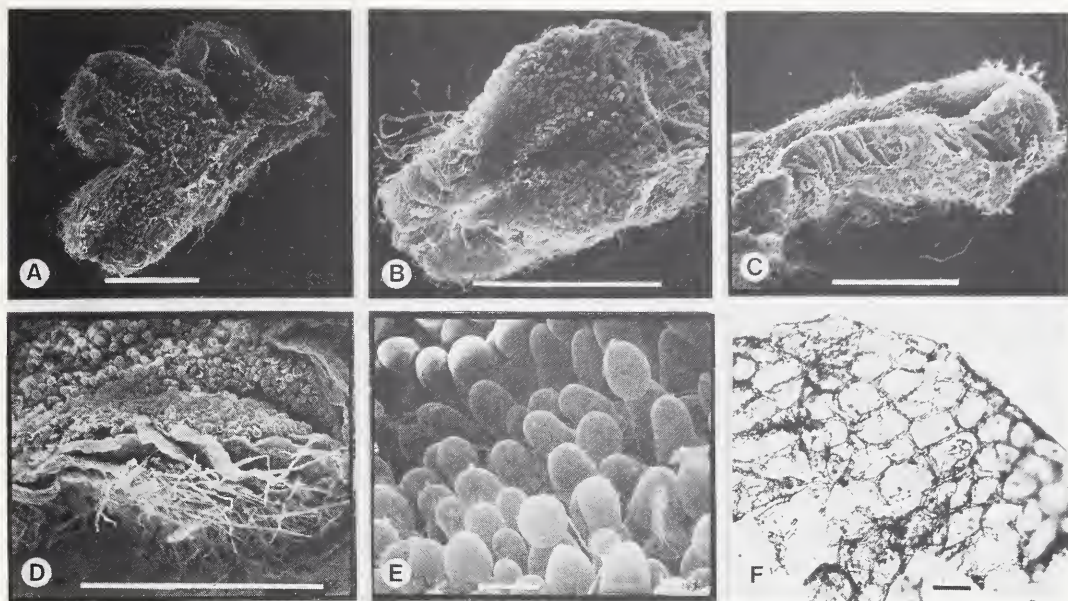


FIGURE 2. —*Riccia albomarginata*. Morphology and anatomy. A, young thallus, field-grown; B, young branch, cultured; C, older branch, cultured; D, scales at margin; E, dorsal cells; F, part of scale. A, *S.M. Perold* 2031; B, C, E, *S.M. Perold* 1979; D, *S.M. Perold* 538; F, *Zeyher* p.p. A–E, SEM micrographs; F, LM micrograph. Scale bar on A–D = 1 mm; E, F = 50 μ m.

not common and its distribution appears to be confined to a few areas in the north-western and south-western Cape (Figure 4), which Zeyher (the other collector referred to by Gottsche *et al.*) is known to have also visited (Gunn & Codd 1981). Although the label on his collection reads 'Prom. b. spei', Gottsche *et al.* reported it to be from 'terra Capensi', which could have been anywhere in the Cape. Krauss's type specimen is from Cape Town (= Caput bonae spei).

SPECIMENS EXAMINED

CAPE. —2918 (Gamoep): Carolusberg, Hester Malan Res., top of mountain, nr old mine, at seepage area and flat granitic rock outcrop (—CA), *S.M. Perold* 1424 p.p., 1425 p.p., 2040 p.p. (PRE). 3017 (Hondeklipbaai): Kamiesberg Pass, dry area above seepage (—BB), *S.M. Perold* 1610 p.p. (PRE); Brakdam, 31 km S of Kamieskroon, dirt road, at rock outcrops (—BD), *S.M. Perold* 2115 p.p. (PRE); 3018 (Kamiesberg): 22 km NE of Garies, Studer's Pass, rock outcrop (—AC), *S.M. Perold* 2124 p.p. (PRE); 5 km E of Garies, on road to Studer's Pass, rock outcrop (—CA), *S.M. Perold* 2118 p.p., 2122 (PRE). 3119 (Calvinia): 2 km from Nieuwoudtville, on road from Vanrhynsdorp, above ditch, on soil between sandstone rocks (—AC), *S.M. Perold* 1756 p.p. (PRE); Nieuwoudtville, Farm Paardekraal, most northerly area of fynbos on escarpment (—AC), *C.M. van Wyk* 1489 (PRE). 3218 (Clanwilliam): 17 km E of Clanwilliam, along Pakhuis Pass, Leipoldt's Grave (—BB), *S.M. Perold* 1930 (PRE); Citrusdal, 20 and 21 km N of Hex River Estates, sandstone rock outcrops above Olifants River (—BD), *S.M. Perold* 538, 2382, 2383 p.p. (PRE). 3219 (Wuppertal): Biedouw Youth Camp, 19 km along road to Wuppertal, on soil over sandstone outcrops, nr waterfall (—AA), *S.M. Perold* 1891 (PRE); 2 km S of Algeria For. Sta., on sandy soil on sandstone rock outcrop (—AC), *S.M. Perold* 2357 (PRE); 21 km from Algeria For. Sta. on road to Cedarberg, opp. ruins of house, on sandy soil at base of rocks (—AC), *S.M. Perold* 1979 (PRE). ? Promontorio Bonae Spei ? terra Capensi (exact locality not known) *Zeyher s.n. in Herb. Gl3117* (G!).

DISCUSSION

The specimen taken to be the type specimen (BM ex Herb. Hampe) has no annotations except '*R. albomarginata*' (hyphenated by Bischoff but not by Krauss)

alpha et beta, Cap. b. sp.' written in Bischoff's hand, as well as his signature on the label. Three small thalli, or groups of thalli, are mounted in three clumps on the herbarium sheet and they represent two different species. Bischoff had given no indication which specimen he considered to belong to *alpha* or to *beta* and Krauss did not refer to any varieties in the protologue. The thallus on the extreme left of the sheet is slightly larger than the others, white and 'fluffy' dorsally (not having been pressed) and could belong to *R. concava* Bisch. ex Krauss. The clump in the middle consists of three small thalli which are slightly brownish, \pm scurfy dorsally and have undulating white margins. I have identified it as *R. albomarginata* and have chosen it as the lectotype. The thallus on the right of the sheet has been affixed with too much glue and is unrecognizable.

The description by Krauss and that by Gottsche *et al.*, which was published only a few months later, are almost identical and are clearly based on the same manuscript by Bischoff. Gottsche *et al.*, however, distinguished two varieties: var. *alpha*, which I consider to belong to *R. albomarginata* and var. *beta maior*, described as larger and having a broader thallus and shorter lobes, which in my opinion, could also represent *R. concava* Bisch. ex Krauss. This var. *beta* is based on a Zeyher collection from the Cape, held at G (ex Herb. Bisch.).

Gottsche *et al.* listed the collections as follows: 'In Promontorio Bonae Spei formam *alpha* leg. Dr Krauss Julio 1838. Eiusdem formae et var. *beta* specimina in terra Capensi lecta retulit cl. Zeyher (Herb. Bisch.)', thus acknowledging the presence of two taxa in the Zeyher collection. The Zeyher collection, however, is also not annotated to distinguish between var. *alpha* and var. *beta*. The collection comprises about nine thalli or fragments of thalli.

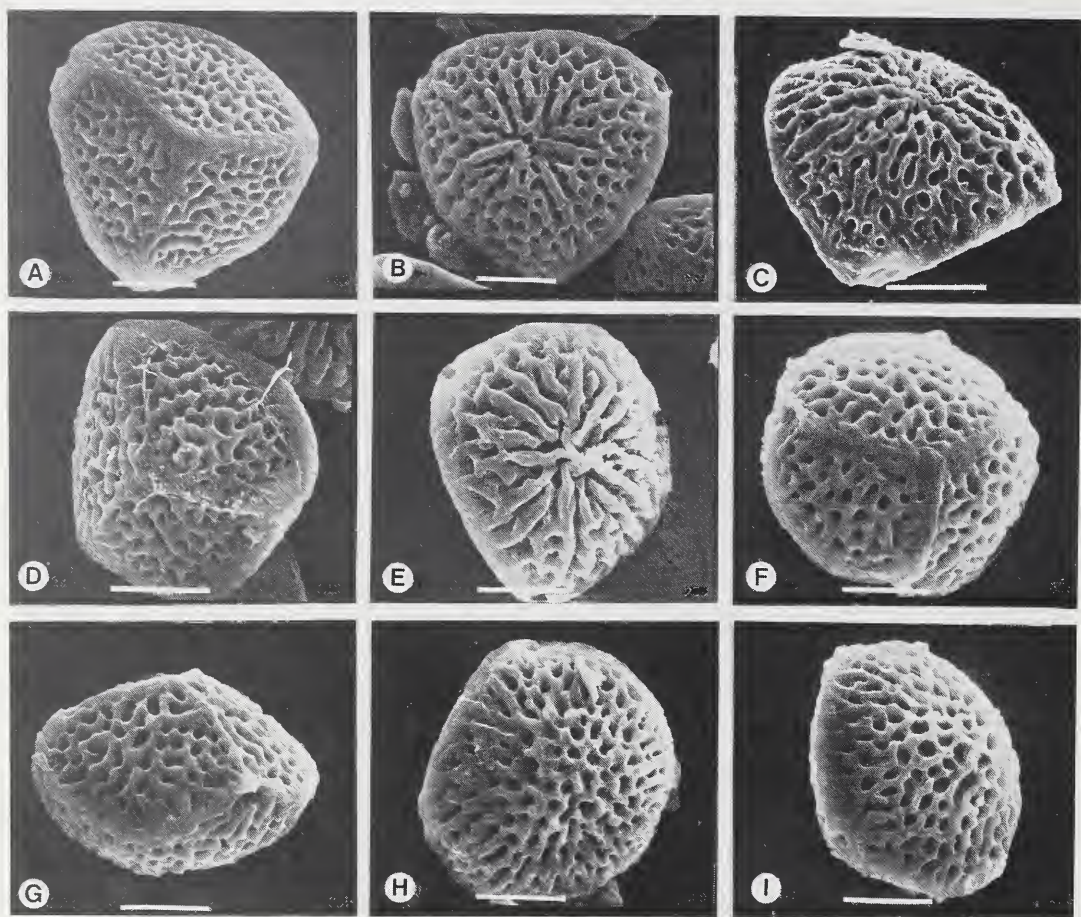


FIGURE 3.—*Riccia albonigata*. Spores. A, D, proximal face; B, E, distal face; C, distal face, side view. A, B, S.M. Perold 2382; C, C.M. van Wyk 1489; D, E, S.M. Perold 538. *Riccia concava*. Spores. F, proximal face; G, proximal face, side view; H, I, distal face. F–I, Zeyher p.p. A–I, SEM micrographs. Scale bar on A–I = 50 μ m.

The two fertile fragments and four somewhat larger thalli could probably also be referable to *R. concava*. These thalli are, however, pressed flat, and are less robust than is usual for this species; they have a somewhat glaucous colour (as noted in the original description of *R. concava*), rounded hyaline scales, which are apically more prominently projecting ($\pm 175 \mu$ m) beyond the margin, and squashed dorsal cells. The remaining two (or three?) smaller thalli in the same packet of this collection are no longer green, but brownish, have flattened, sparse, fine threads dorsally and \pm undulating white, membranous scales above purple-brown flanks. They are here identified as *R. albonigata* var. *alpha*. The single thallus in the other packet of the Zeyher collection (and presumably the one Stephani may have sectioned) is very thin, as it has been pressed quite flat and is therefore unidentifiable.

The spores from the above Zeyher collection (Figure 3F–I) are closely similar in their ornamentation to those of *R. concava* as noted above. They are 75–90 μ m in diameter, triangular-globular, polar, bright brown, semi-transparent to opaque; wing $\pm 5 \mu$ m wide, margin almost smooth; ornamentation reticulate: distal face with ± 13 areolae across diameter, $\pm 5 \mu$ m wide, walls thick, smooth, raised at nodes; proximal face with triradial mark

distinct, ornamentation similar to that on distal face (compare with Figure 3, No. 14 in the series 'Studies in the genus *Riccia* from southern Africa', Perold 1989a and also Perold 1989b, Fig. 26). Volk (1983) also suspected

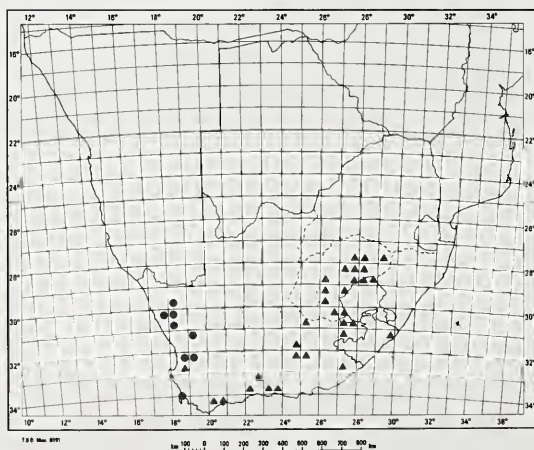


FIGURE 4.—Distribution map of *R. albonigata*, ●, and *R. simii*, ▲, in southern Africa.

that Stephani's (1898) description and illustration of the spores from Zeyher's collection of *R. albomarginata* in his previously unpublished *Icones hepaticarum* (G), were actually of *R. concava* spores.

In their description of *R. concava*, which follows immediately on that of *R. albomarginata* (but which they placed in a different section, 'Subtus Squamatae' and not in the Ciliatae, Gottsche *et al.* noted that *R. concava* was similar to *R. albomarginata* var. *beta maior* (and to *R. lamellosa*). This apparent similarity between a part of both collections and *R. concava*, was also found in the present investigation as noted above.

Because of the fragmentary nature and generally poor condition of the type material and the adverse effects of cleaning and pressing the Zeyher collection, only the habit, scales and to some extent, the colour of the thalli, could be checked for each species and were found to be correct. Other characters, such as the vitally important shape and size of the cells in the dorsal pillars and the shape of the thalli in cross section, could not be checked at all, unfortunately. Marginal cilia are definitely absent.

Later authors, such as Stephani (1898), who incidentally had only seen Zeyher's collection, again ignored the fact that the collections were mixed, and treated them as a single species with prominent scales, disregarding the reference to small membranes, proximally not divided into separate lamellae (fide Gottsche *et al.*). Sim (1926) applied the name to a different taxon (see below), Arnell (1957, 1963) to yet another, and Volk (1981, 1983) followed Sim; the specimens from Ile de l'Est (Crozet Archipelago), assigned to *R. albomarginata* Bisch. ex G.L. & N. emend. Sim by Jovet-Ast (1986) have not been seen by me, but it is my opinion that their identity should be reconsidered.

CLASSIFICATION OF *R. ALBOMARGINATA*

R. albomarginata Bisch. belongs to section *Pilifer* Volk, characterized by free-standing, multicellular dorsal epithelial pillars and only lately recognized as a distinct group by Volk (1983) and also by Schuster (1984, 1985) as his subgenus *Pteroriccia*. Gottsche *et al.* (1846) had incorrectly classified *R. albomarginata* under the Ciliatae, which have unicellular marginal hairs, although *R. concava* Bisch., which they regarded as similar to *R. albomarginata* (var. *beta maior*), was classified under a different group, 'Subtus Squamatae'. However, it appears from Bischoff's observations when referring to *R. concava* (quoted by G.L. & N.), that the 'small scales' in the dry plants could be taken for cilia!

Stephani (1898) placed *R. albomarginata* in his *Inermes* (without cilia) and also failed to report on the dorsal epithelial cell pillars. Admittedly, in the pressed, dried plants of the original material, they are very difficult to recognize.

In his key to the *Riccia* species, Arnell (1963) grouped *R. albomarginata* and *R. concava* together with a ciliated species, *R. natalensis*, partly following Sim (1926) who had classified *R. albomarginata*, *R. natalensis* and his untraced species, *R. coronata*, together under the heading 'epidermal cells, or some of them, elongated or mammillate and free'. It is therefore obvious that earlier authors did

not have a clear understanding of the difference between unicellular marginal cilia and multicellular hairs covering the entire dorsal face of the thallus.

MISAPPLICATION OF *R. ALBOMARGINATA*

From his own and Potts's collections, Sim was familiar with a *Riccia* species with large white scales to which he applied the specific name 'albomarginata'. This species is further characterized by 'upper pillars quite free from one another...' which he (Sim 1926) proceeded to describe and illustrate, but without citing specimens. Sim could of course examine fresh material (with the dorsal pillars intact and not collapsed, as they are in long-dried specimens) and this admittedly gave him an advantage denied the earlier workers, who in any case, were totally unfamiliar with such cell pillars.

Whether the specimens of *R. albomarginata* Bisch. cited by Krauss and by G.L. & N. were less fragmentary and in a better state of preservation in Sim's time, is not known. However, Sim evidently noticed signs of loose dorsal pillars in the type specimens [although he overlooked them in *R. concava* (Perold 1989)] and assumed that his and Potts's collections, presumably the only ones to his knowledge with similar pillars, belonged to *R. albomarginata*.

Volk (1983) finds it 'erstaunlich, dass Bischoff die Haare des Epithels nicht erwähnt', but I venture to state, that, if Bischoff had indeed been dealing with *R. albomarginata* auct. non Bisch., he, Krauss and Gottsche *et al.* could not have failed to notice the thick velvety dorsal covering of the thallus, which is still very evident in Sim 338, a hundred years after collection and also after experimental pressing by me.

Earlier, Stephani had remarked on the 'ganz dünnes Laub' of *R. albomarginata* Bisch., which could have referred to either var. *alpha* or var. *beta*, but certainly not to the plants described by Sim as 2 mm thick in cross section. Even if subjected to prolonged pressing, such thick lobes could not have been flattened to the almost paper-like thinness of some of the type material.

Finally, the scales of *R. albomarginata* auct. non Bisch. are very prominent, wavy, white, and apparently with some striations on the cell surfaces (Figure 6F), unlike the smaller ($\pm 600 \times 325-450 \mu\text{m}$), clear, hyaline or white membranous scales (Figure 2F) of the type. Sim may also have been misled by Stephani's comments that the scales of Zeyher's plants were prominent, extending much above the thallus margins (but only up to ± 150 and $175 \mu\text{m}$ in the two varieties *alpha* and *beta* respectively, as measured by me), and that the species had been named for this reason (see under *R. albomarginata* Bisch.). Sim did not describe spores for his species.

The concluding remark in Sim's (1926) description of *R. albomarginata* (p. 10) viz.: '*R. villosa* Steph. (Brunnthaller 1913, p.p. 1-14), from Matjiesfontein, C.P. (an arid locality) answers the description exactly', raises doubts whether he had thoroughly examined the type specimens of either species, as *R. albomarginata* has rounded scales and *R. villosa* has triangular scales.

Arnell (1963) gave only a very brief description of *R. albomarginata* auct. non Bisch. The spore illustrations and description (Arnell 1963) were based on Volk 12433 p.p. and 12462 p.p. (Arnell 1957), collected in SWA/Namibia, and reassigned to *R. albovestita* Volk (Volk 1981).

Regardless of what influenced Sim, it is now indisputable that he misapplied the specific name *albomarginata* to a species which is here named and described as *R. simii*, sp. nov. The specific epithet, *simii*, has been chosen in deference to Sim's work, as he was the first to describe and illustrate free-standing dorsal epithelial cell pillars in a *Riccia* species.

***Riccia simii* Perold, sp. nov.**

R. albomarginata auct. non Bisch.: Sim: 9 (1926); Volk: 453 (1983).

Thallus monoicus, perennis, magnitudine medius vel magnus, in vivo smaragdinus, velutinus, squamis magnis, hyalinis, marginis in sicco squamis supra paginam dorsalem granularem inflexis. **Frons** usque ad 12 mm longa, 1,8–2,5 mm lata, 0,9–1,3(–1,5) mm crassa, in sectione transversali duplo latiora quam crassa, symmetrica vel asymmetrica furcata, oblonga vel obovata, apice acuta, marginibus subacutis, apicem versus dorsaliter sulcata, aliter plana, ad latera verticalis vel obliquiter proximaliter deversa. **Anatomia**: epithelium dorsale 350 μ m crassum, ex columnis liberis deminuentibus, 4–5-cellularibus fragilibus compositum; aerenchyma 350 μ m crassa, textura penaria 400 μ m. **Squamae** magnae, 1500 \times 600–900 μ m, rotundatae, hyalinae, crebre imbricatae, plus quam 250 μ m supra margines thalli eminentes. **Sporae** (70–)82–105(–120) μ m diametro, deltoideo-globulares, ala \pm 5 μ m lata; ornameto variabile, perfecte vel imperfecte reticulato; pagina distali seriebus areolarum omnibus vel solum exterioribus completis, 5–10 μ m latis, parietibus irregulariter ramificantibus vel in cristis radiantibus; pagina proximali nota triradiata distincta, in quoque superficie 25–30 areolis parvis.

TYPE.—Cape, 3227 (Stutterheim): Perie Mission Station, Kaffraria (–CC). *T.R. Sim 338 (PRE-CH 1035)* (PRE, holo.) alt. 2500 ft., 1888.

Thallus monoicous, perennial, in crowded gregarious patches or scattered, bright green to emerald green, velvety, with large hyaline scales (Figure 6D) extending above and beyond thallus margins (Figures 5A; 6A); medium-sized to large, branches simple or one to twice symmetrically or asymmetrically furcate, medium to widely divergent, up to 12,0 mm long segments 4,0–5,0 mm long, 1,8–2,5 mm wide, 0,9–1,3(–1,5) mm thick, i.e. \pm twice wider than thick in section (Figure 5E); oblong to obovate (Figure 6B), apex acute (Figure 6C), dorsal face distally deeply grooved, soon becoming flat; margins subacute, flanks steep to proximally sloping obliquely upward and outward, green, sometimes flecked with violet, covered with large scales; ventral face gently rounded to flat, green; when dry (Figure 5B), margins tightly inflexed, apically meeting along midline over white, finely granular dorsal surface, scales white, imbricate, wavy.

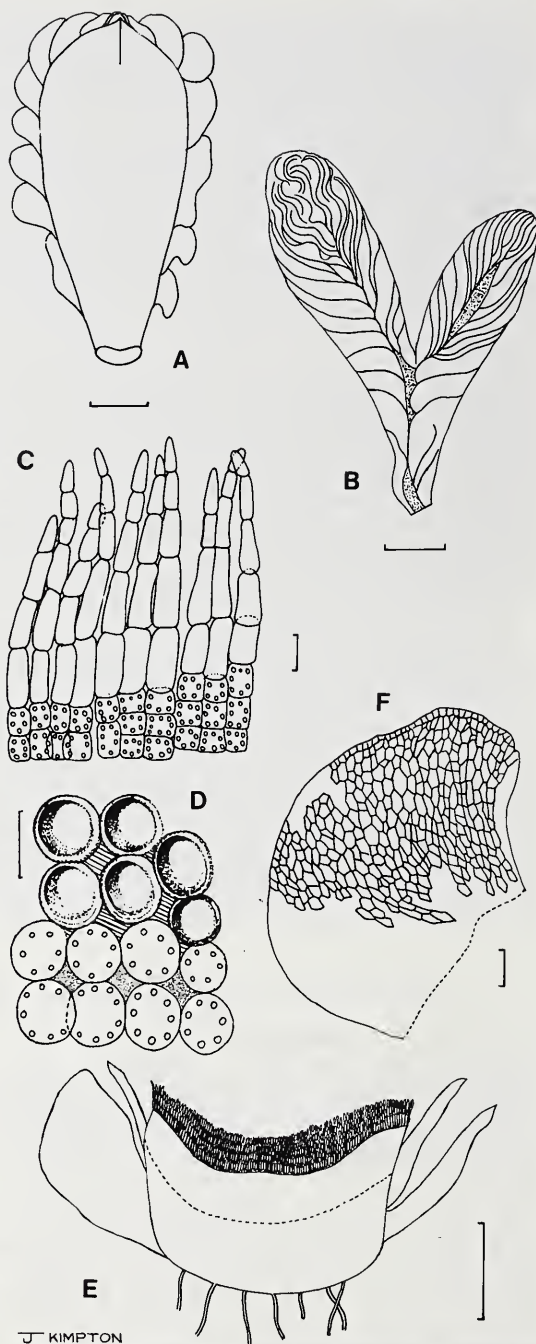


FIGURE 5.—*Riccia simii*. Morphology and anatomy. A, thallus wet; B, thallus dry; C, transverse section through dorsal cell pillars; D, horizontal section through basal cells of cell pillars with air pores hatched, and through assimilation tissue with air canals stippled; E, transverse section through thallus; F, scale. A, E, S.M. Perold 1318; B, S.M. Perold 1346; C, S.M. Perold 505; D, Smook 6631; F, C.M. van Wyk 1781. Drawings by J. Kimpton. Scale bar on A, B, E = 1 mm; C, D = 50 μ m; F = 100 μ m.

Anatomy of thallus: dorsal epithelium (Figures 5C; 6E) consisting of free-standing, 4–5-celled, gradually tapering pillars, fragile, but basally somewhat thicker-walled,

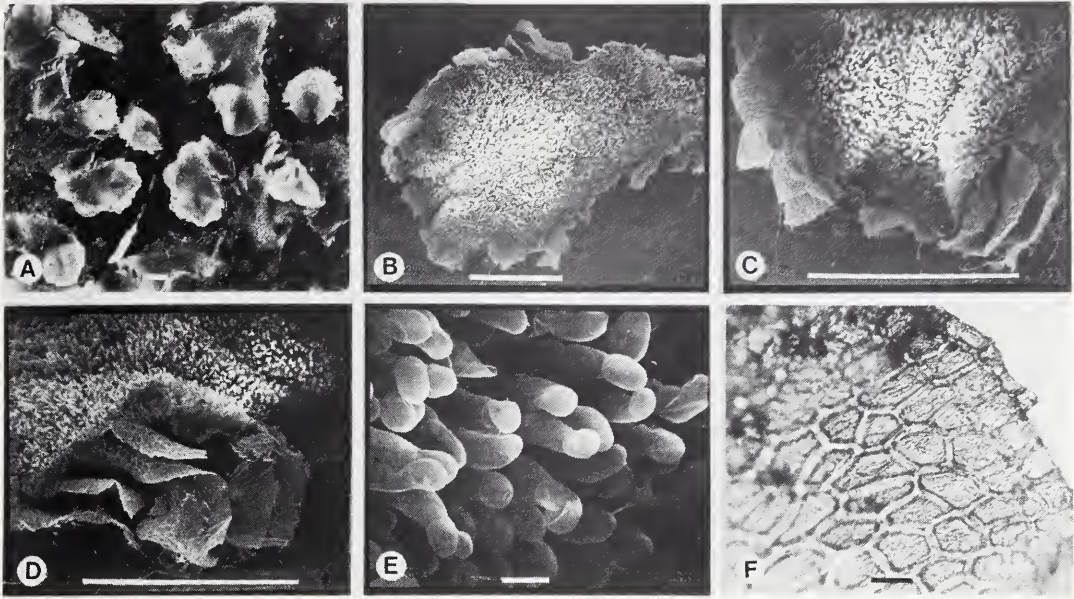


FIGURE 6. — *Riccia simii*. Morphology and anatomy. A, thalli in cultivation; B, branch from field-grown thallus; C, apex of same; D, scales near apex; E, dorsal cell pillars; F, part of scale showing striations. A, J. Thompson 257; B–E, S.M. Perold 505; F, S.M. Perold 1348. A, by A. Romanowski; B–E, SEM micrographs; F, LM micrograph. Scale bar on A = 1 mm; B–F = 50 μ m.

hyaline, up to $\pm 350 \mu$ m long, apical cells $25\text{--}50 \times 18\text{--}25 \mu$ m, intermediate cells $45\text{--}75(\text{--}80) \times 25\text{--}35 \mu$ m, basal cells $62\text{--}80 \times 30\text{--}38 \mu$ m, mostly equally long, with upper transverse walls in an interrupted horizontal line across; from above, pillars forming a thick pelt, mostly collapsed proximally, air pores small, 4–6(–8)-sided (Figure 5D), obscured by cell pillars; assimilation tissue $\pm 350 \mu$ m thick in section, $\frac{1}{3}$ the thickness of thallus and consisting of vertical columns of up to 8 cells, $\pm 40 \times 25 \mu$ m, enclosing narrow 4–5-sided air canals; storage tissue $\pm 400 \mu$ m thick, $\frac{1}{3}$ the thickness of thallus, cells rounded to angular, closely packed, $\pm 50 \mu$ m wide; rhizoids arising from ventral epidermal cells, some smooth, others tuberculate, 22μ m wide. *Scales* (Figures 5F; 6F) nearly semi-circular, large, closely imbricate, projecting more than 250μ m above thallus margins, hyaline, up to $1500 \times 600\text{--}900 \mu$ m, margins smooth, cells often with somewhat striate surface, in body of scale long-hexagonal or rectangular, $80\text{--}110(\text{--}125) \times 30\text{--}35(\text{--}40) \mu$ m, at margins ± 2 rows of smaller brick-shaped cells. *Antheridia* with hyaline necks, extending nearly 500μ m above dorsal surface. *Archegonia* with purple necks, scattered along median part of thallus. *Sporangia* mostly single, rarely up to 3 crowded together in narrow basal part of thallus, dorsally bulging, each with $\pm 370\text{--}400$ spores, but thalli only very occasionally sporulating. *Spores* $(70\text{--})82\text{--}105(\text{--}120) \mu$ m in diameter, triangular-globular, polar, yellow or light brown, colour deepening to mahogany brown or turning black on ageing, semitransparent to opaque, with wing $\pm 5 \mu$ m wide, margin finely crenulate, angles perforated; ornamentation variable, completely or incompletely reticulate, similar or dissimilar on two spore faces: distal face (Figure 7B, D, F) with all, or only outer rows of areolae complete, variable in size, $5\text{--}10 \mu$ m wide, irregularly shaped, rounded or elongated, walls raised at nodes, sometimes anastomosing to form ridges, irregularly branching and

twisting or radiating outwards from centre; proximal face (Figure 7A, C, E) with triradiate mark clearly defined, sometimes papillate, $25\text{--}30$ complete or incomplete small areolae, up to 5μ m wide, on each of 3 facets, walls thin, raised at nodes, sometimes sprinkled with papillae towards wing.

R. simii can be distinguished from other species in section *Pilifer*, subgenus *Riccia*, by the rounded, very large, wavy, closely imbricate, hyaline scales, projecting much beyond the thallus margins and by the velvety dorsal surface of the thallus, with the tapering cell pillars apically 'finer' than those in other species, except for *R. villosa*, which has triangular scales and is strictly confined to the north-western, south-western and southern Cape. *R. simii* is fairly common in the Orange Free State and is also known from the south-western, southern, central and eastern Cape and from Transkei (Figure 4). Sim (1926) reported this species, *R. simii* (= *R. albomarginata* auct. non Bisch.), from Transvaal and Natal, but this has not been verified. Plants that he collected from Southern Rhodesia (Zimbabwe), *Sim* 9068–9070, 9072 (PRE), and identified as *R. albomarginata* Bisch. ex G.L. & N. (Sim 1931), are in fact *R. moenkemeyeri* Steph. Curiously, Sim had identified his collection, *Sim* 338 (PRE-CH1035), here selected as the holotype of *R. simii*, as *R. limbata*, which has black scales. It was subsequently identified as *R. albomarginata*, presumably by Duthie or Arnell.

R. simii is found on shallow soil overlying rock outcrops, which can be sandstone, dolerite or even limestone. It grows in association with other *Riccia* species, and occasionally with *Mannia capensis* (Steph.) S. Arnell, and with small succulents, in both summer and winter rainfall areas.

Volk (1983) chose this species, under the name *R. albo-marginata*, as the type species of his section *Pilifer* and provided a detailed description.

SPECIMENS EXAMINED

O.F.S. — 2727 (Kroonstad): grassland, on Farm Caroline, 8 km SE of Steynsrus (—DC), *Smook* 6631 (PRE). 2728 (Frankfort): Wonderfontein, 40 km from Bethlehem on road to Lindley (—CC), *S.M. Perold* 1366 (PRE). 2729 (Volksrust): Farm Witkoppe, SE of Vrede (—CB), *Smook* 6418 (PRE). 2826 (Brandfort): Brandfort (—CB), *Duthie* 5330 (BOL). 2827 (Senekal): Allemanskraal, 5 km from Ventersburg (—AC), on dolerite, *Volk* 81/226, 1984/730 (M, PRE); Senekal, on koppie behind town (—BC), *S.M. Perold* 1337, 1341 (PRE); Paul Roux, on flat rocks on koppie behind town (—BD), *S.M. Perold* 1346 (PRE); 6 km N of Cloccolan, on road to Marquard, nr bridge, on flat weathered sandstone rocks (—DC), *S.M. Perold* 1323 (PRE); on flat rocks on Farm Holstein, on road to Ficksburg, 22 km E of Cloccolan (—DC), *S.M. Perold* 1318 (PRE). 2828 (Bethlehem): on koppie at HF tower (—AB), *S.M. Perold* 1360, 1363 (PRE); 14 km E of Paul Roux, on road to Bethlehem, on weathered sandstone (—AC), *S.M. Perold* 1353 (PRE); 11 km E of Fouriesburg, on slope next to road to Clarens (—CB), *S.M. Perold* 1304, 1306 (PRE); on rocky outcrop nr Golden Gate Highland Park, between Clarens and Kestell (—DA), *J.M. Perold* 29 (PRE). 2926 (Bloemfontein): Bloemfontein, Eagle's Nest (—AA), *Duthie* 5456, 5461 (BOL); *Geo. Potts* PRE-CH 1101 (PRE); Rayton Caravan Park, *Volk* 81/051, 81/289a (M, PRE); Uitskyhoogte, along road from Reddersburg to van Stadensrus via Helvetia (—CD), *Van Rooy* 2337, 2338 (PRE). 2927 (Maseru): 10 and 12 km S of Ladybrand, on shallow soil on road R26 (—AB), *J.M. Perold* 36, 39, 43, 44 p.p. (PRE). 3026 (Aliwal North): NE of Zastron, edge of small pan in grassland on Farm Elandsberg (—BB), *Van Rooy* 2403 (PRE); between Zastron and Wesselsdale, Farm Olievenrand (—BB), *Van Rooy* 2416 (PRE). 3027 (Lady Grey): Zastron, on soil under sandstone overhang on E slopes of Aasvoëlberg (—AC), *Van Rooy* 2515 (PRE).

TRANSKEI. — 3129 (Port St. Johns): Holy Cross Mission, 1,6 km along road to Flagstaff, on soil over flat sandstone (—BA), *Van Rooy* 1817, 1818, 1823 (PRE); sandstone outcrops in grassland, 22 km from Holy Cross Mission on road to Mkanbati (—BB), *Van Rooy* 1708a (PRE).

CAPE. — 3025 (Colesberg): Colesberg Dist., on koppie between rocks and shrubs (—CA), *Hitchcock* 5478 (BOL). 3027 (Lady Grey): on soil over sandstone between Farms Rietfontein and De Kraal, 23 km S of Lady Grey (—CC), *Van Rooy* 2602 (PRE); on soil over sandstone, Farm

Ferngrove, on road to Jamestown, 14 km from Lady Grey (—CC), *Van Rooy* 2685 (PRE); 17 km from Barkly East to Rhodes, on cave sandstone, at Rebelhoogte, near Farm La Colleen (—DC), *Van Rooy* 2766 (PRE). 3124 (Hanover): on soil at edge of dry stream on road to Middelburg, 1 km S of Lootsberg Pass (—DB), *S.M. Perold* 949 (PRE). 3127 (Lady Frere): on shallow soil nr seepage nr Farm Clifford between Barkly East and Rossouw (—AB), *Thompson* 257 (PRE). 3218 (Clanwilliam): on flat rock outcrop, above Platklouf River, Farm Middelpas, on road to Goedverwag NW of Piketberg (—DC), *S.M. Perold* 505 (PRE). 3224 (Graaff Reinet): Valley of Desolation, at lookout, on flat rock outcrops (—BC), *Smook* 3908 (PRE). 3225 (Somerset East): Cradock Mountain Zebra Park (—AD), *Liebenberg* 7632 (PRE). 3227 (Stutterheim): Perie Mission Sta. (—CC), *Sim* 338 (PRE-CH 1035) (holotype) (PRE). 3322 (Oudtshoorn): 15 km from De Rust, on road to Uniondale (—BC), *Koekemoer* 291 (PRE); 5 km from Dysseldorp on road to Kammanassie Dam (—CB), *Koekemoer* 292 (PRE). 3323 (Willowmore): Uniondale, Vervlei (—CA), *Duthie* 22 (PRE-CH 1016) (PRE); Langklouf Mts. (—DC), *Duthie* 5115 (BOL). 3420 (Bredasdorp): De Hoop area, in pass on road from Wydgeleë to De Hoop, between fynbos on slope (—AD), *Fellingham* 746 (PRE); NW of Cape Infanta, Potteberg Estates, Farm Witwater, on S facing limestone slopes with fynbos (—BD), *Oliver* 8490 (PRE); De Hoop, Buffelsfontein, on moist sandy patches between fynbos (—CB), *C.M. van Wyk* 1781 (PRE).

CORRECTION

Unbeknown to me and therefore previously omitted (Perold 1989; Perold & Volk 1988), Krauss had also published brief but validly published descriptions of *Riccia concava* Bisch. and *R. limbata* Bisch. in *Flora* 29: 135, 136 in March 1846, thereby antedating the publication of the description of these two species (and *R. albomarginata*) by Gottsche *et al.* in *Synopsis hepaticarum* Oct. 1846, by seven months (fide Grolle pers. comm.).

ACKNOWLEDGEMENTS

Sincere thanks are due to the curators of BM, G and BOL herbaria for the loan of the type and other specimens. I gratefully acknowledge information from Dr R. Grolle,

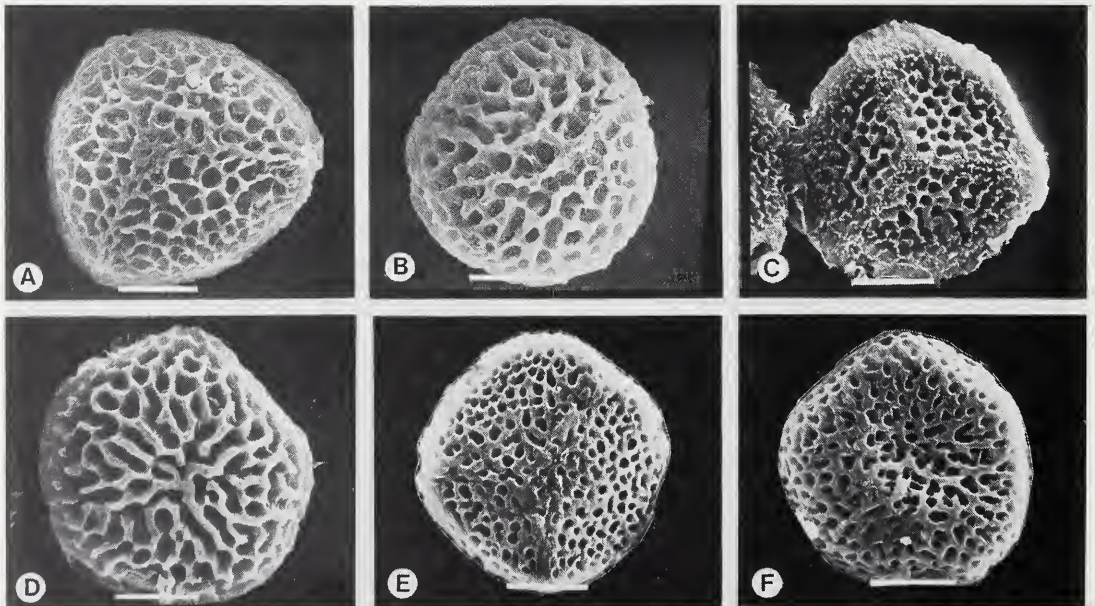


FIGURE 7.—*Riccia simii*. Spores. A, C, E, proximal face; B, D, F, distal face. A, B, *J.M. Perold* 39; C, D, *Volk* 81/289a; E, F, *Sim* 338. Scale bar on A–F = 50 μ m. All micrographs by S.M. Perold.

Friedrich Schiller University, Jena, concerning the Krauss publication and the dates of the publication by Krauss and by Gottsche *et al.*, as well as the typification. I am also grateful for discussions with, and advice from Messrs J. van Rooy and F. Brusse as well as Dr H.F. Glen, who also translated the Latin texts and suggested the specific epithet, *simii*. Photographs were prepared by Mrs A. Romanowski and the line drawings are by Ms J. Kimpton, for which they are both sincerely thanked. Dr E.W. Jones, Oxford, Dr E.O. Campbell, Massey University, New Zealand and Prof. O.H. Volk, Würzburg University, commented on the manuscript and I owe them a large debt of gratitude. Prof. Volk was also instrumental in obtaining the information referred to above, from Dr Grolle.

REFERENCES

- ARNELL, S. 1957. Hepaticae collected in South West Africa by Prof. Dr O.H. Volk, *Mitteilungen aus der Botanischen Staatssammlung, München* 16: 262–272.
- ARNELL, S. 1963. *Hepaticae of South Africa*, pp. 411. Swedish Natural Science Council, Stockholm.
- GOTTSCHE, C.M., LINDENBERG, J.B.G. & NEES ab ESENBECK, C.G. 1844–1847. *Synopsis hepaticarum*, pp. 835. Hamburg. Reprinted 1967.
- GUNN, M. & CODD, L.E. 1981. *Botanical exploration of southern Africa*, pp. 400. Balkema, Cape Town.
- JOVET-AST, S. 1986. *Riccia* de l' Archipel des Crozet (Ile de l'Est). *Cryptogamie, Bryologie et Lichénologie* 7: 479–485.
- KRAUSS, F. 1846. Pflanzen des Cap- und Natal-Landes, gesammelt und zusammengestellt von Dr Ferdinand Krauss. *Flora* 29: 135, 136.
- PEROLD, S.M. 1986. *Pteroriccia* Schust., should it be upheld? (Ricciaceae). *Bothalia* 16: 63–64.
- PEROLD, S.M. 1989a. Studies in the genus *Riccia* (Marchantiales) from southern Africa. 14. *R. concava* section *Pilifer*. *Bothalia* 19: 161–165.
- PEROLD, S.M. 1989b. Spore-wall ornamentation as an aid in identifying the southern African species of *Riccia* (Hepaticae). *Journal of the Hattori Botanical Laboratory* 67: 109–201.
- PEROLD, S.M. In press. Studies in the genus *Riccia* (Marchantiales) from southern Africa. 17. Three new species in section *Pilifer*: *R. elongata*, *R. ampullacea* and *R. trachyglossum*. *Bothalia*.
- PEROLD, S.M. & VOLK, O.H. 1988. Studies in the genus *Riccia* (Marchantiales) from southern Africa. 9. *R. nigrella* and the status of *R. capensis*. *Bothalia* 18: 43–49.
- SCHUSTER, R.M. 1984. Diagnoses of some new taxa of Hepaticae. *Phytologia* 56: 65–74.
- SCHUSTER, R.M. 1985. Some new taxa of Hepaticae. *Phytologia* 57: 408–414.
- SIM, T.R. 1926. The bryophyta of South Africa. *Transactions of the Royal Society of South Africa* 15: 9, 10.
- SIM, T.R. 1931. South African Bryophytes. Further notes. *Transactions of the Royal Society of South Africa* 20: 15–17.
- STEPHANI, F. 1898. Species hepaticarum. *Bulletin de l' Herbarium Boissier* 6: 309–411.
- STEPHANI, F. 1876–1907. *Icones hepaticarum*. Ed. P. Geissler. IDS Microform Publishers, Zug, Switzerland, publ. 1986.
- VOLK, O.H. 1981. Beiträge zur Kenntnis der Lebermoose (Hepaticae) aus Südwestafrika (Namibia). II. *Mitteilungen der Botanischen Staatssammlung, München* 17: 245–252.
- VOLK, O.H. 1983. Vorschlag für eine Neugliederung der Gattung *Riccia* L. *Mitteilungen der Botanischen Staatssammlung, München* 19: 453–465.

New species of *Erica* (Ericaceae) from the Cape Province

E.G.H. OLIVER*

Keywords: Cape Province, *Erica*, new species, taxonomy

ABSTRACT

Three new species of *Erica* L. (Ericaceae) are described from the southern parts of the Cape Province. *E. amicum* E.G.H. Oliver, an endemic marsh species from the Langeberg near Riversdale, is one of the most distinctive species in the genus on account of its almost free reflexed petals, reflexed stamens and exserted gynoeceum. The mat-forming *E. tegetiformis* E.G.H. Oliver is allied to *E. senilis* Klotzsch ex Benth. and *E. eriophoros* Guth. & Bol., all occurring at high altitudes in the Cold Bokkeveld and Cedarberg. *E. cunoniensis* E.G.H. Oliver is allied to the *E. squarrosa* Salisb./*E. gysbertii* Guth. & Bol. complex and is very localized in the mountains of the western part of the Caledon Division near Rooi Els.

UITTREKSEL

Drie nuwe spesies van *Erica* L. (Ericaceae) van die suidelike dele van die Kaap Provinsie word beskryf. *E. amicum* E.G.H. Oliver, 'n endemiese moeras-spesies van die Langeberg naby Riversdal, is een van die merkwaardigste spesies in die genus omdat dit byna vry teruggebuigde kroonblare, teruggebuigde meeldrade en 'n ontblote ginesium het. *E. tegetiformis* E.G.H. Oliver, wat groot matte vorm, is naverwant aan *E. senilis* Klotzsch ex Benth. en *E. eriophoros* Guth. & Bol., en al drie kom voor op hoë plekke in die Koue Bokkeveld en Sederberge. *E. cunoniensis* E.G.H. Oliver is naverwant aan die *E. squarrosa* Salisb./*E. gysbertii* Guth. & Bol. kompleks en het 'n beperkte verspreiding in die berge van die westelike gedeelte van die Caledon distrik naby Rooi Els.

INTRODUCTION

The genus *Erica* in southern Africa has recently been increased in size with the inclusion of the 15 species of *Philippia* Klotzsch (Oliver 1987, 1988) and now contains some 654 species. As such it is by far the largest genus in the flora of southern Africa, indeed the continent of Africa. The considerable increase in collections of plants from the region of the Cape Flora during the last three to four decades has produced a wealth of new and interesting records. These include a number of distinct undescribed species of which three are described here.

Erica amicum E.G.H. Oliver, sp. nov., in genere distinctissima et singularis propter lobos corollae subliberos reflexos stamina erecta deinde reflexa et gynoeceum exsertum, sed aspectu typico specierum sectionis Ceramiae.

Fruticulus prostratus repens. *Rami* ad 1,5 m longi glabri internodiis longis cortice irregulari grisei. *Folia* 3-nata, 5–6 × 4–4,5 mm patentia ovata ad subcircularia apice attenuato marginibus leviter invaginati ad subnaviculata, ciliata pilis parvis et pilis crassis glandulosis adaxiale puberula abaxiale pubescentia pilis crispis, petiolo 0,8–1,0 mm longo puberulo. *Flores* 1–2 in extremis brachyblastorum lateralium absolutorum vel 1–3 in extremis ramulorum; pedicellum 3–5 mm longum ad basim crassum glabrum vel juniores interdum puberulum; bractea 0,5–1,0 mm longa basalis vel submedianae anguste ovata vel elliptico-oblonga; bracteolae 2 oppositae subbasales ad submedianae 0,4–0,7 mm longae. *Calyx* profunde 4-lobatus subliber, lobis 1,7 × 1,5 mm late ovatis initio erectis demum reflexis ciliatis rosellis atrorubrescentibus. *Corolla* profunde 4-lobata, tubo 0,8 mm longa latissime

cyathiformis, lobis 2,9 × 2,2 mm, late naviculato-ellipticis, patentibus demum reflexis, puberulis ciliatis pilis parvis et 5–6 glandulis, rosellis atrorubrescentibus. *Stamina* 8 exserta initio erecta demum reflexa; filamenta 2 mm longa subteretia in annulo base conjuncta, glabra apice dentata; antherae erectae dorsales, thecis 1,2 mm longis obtusis parum prognathis scabridulosis muticis, poro theca 3-plo brevior; pollen in tetradis. *Ovarium* manifestum demum omnino exsertum, depresso-globosum echinoideum pilis brevibus longis glandulosis tectis, disco base; stylus exsertus filiformis 2,8–3,2 mm longus; stigma simplex. *Capsula* globosa glanduloso-setosa, seminibus ellipsoideis ad subsphaericis reticulatis. Figura 1.

TYPE.—Cape, Riversdale District, the Langeberg, south slopes at head of Valsrivier, 609 m, 12 December 1987, *Oliver, Schumann & Kirsten 9054* (STE, holo.; BM, BOL, E, G, K, MO, NBG, NY, P, PRE, S).

Prostrate delicate creeping shrublet. *Branches* up to 1,5 m long spreading through restioid vegetation, glabrous, brown, with long internodes, side branches often curved, bark irregularly sloughing off in grey portions. *Leaves* 3-nate, 5–6 × 4–4,5 mm, patent, ovate to subcircular with an attenuate apex and slightly inrolled margins to subnaviculate, ciliate with very short hairs and long stout hairs, sparsely puberulous adaxially when young, sometimes glandular-ciliate along the pseudomargin adaxially, crisped pubescent abaxially and with a few stout gland-tipped hairs along the midrib; petiole 0,8–1,0 mm long, puberulous when young, ciliate. *Flowers* 1–2-nate at ends of lateral absolute brachyblasts or 1–3-nate at ends of branchlets, sometimes mixed in a synflorescence; pedicel 3–5 mm long tapering to the base, glabrous or sparsely glandular villous, sometimes puberulous when young, dark red; bract 0,5–1,0 mm long, basal, occasionally submedian, narrowly attenuate-ovate or elliptic-oblong, with or without a sulcate tip; bracteoles 2, opposite, subbasal to submedian, 0,4–0,7 mm long elliptic-

* Stellenbosch Herbarium, National Botanical Institute, P.O. Box 471, Stellenbosch 7600.

MS. received: 1989.04.03.

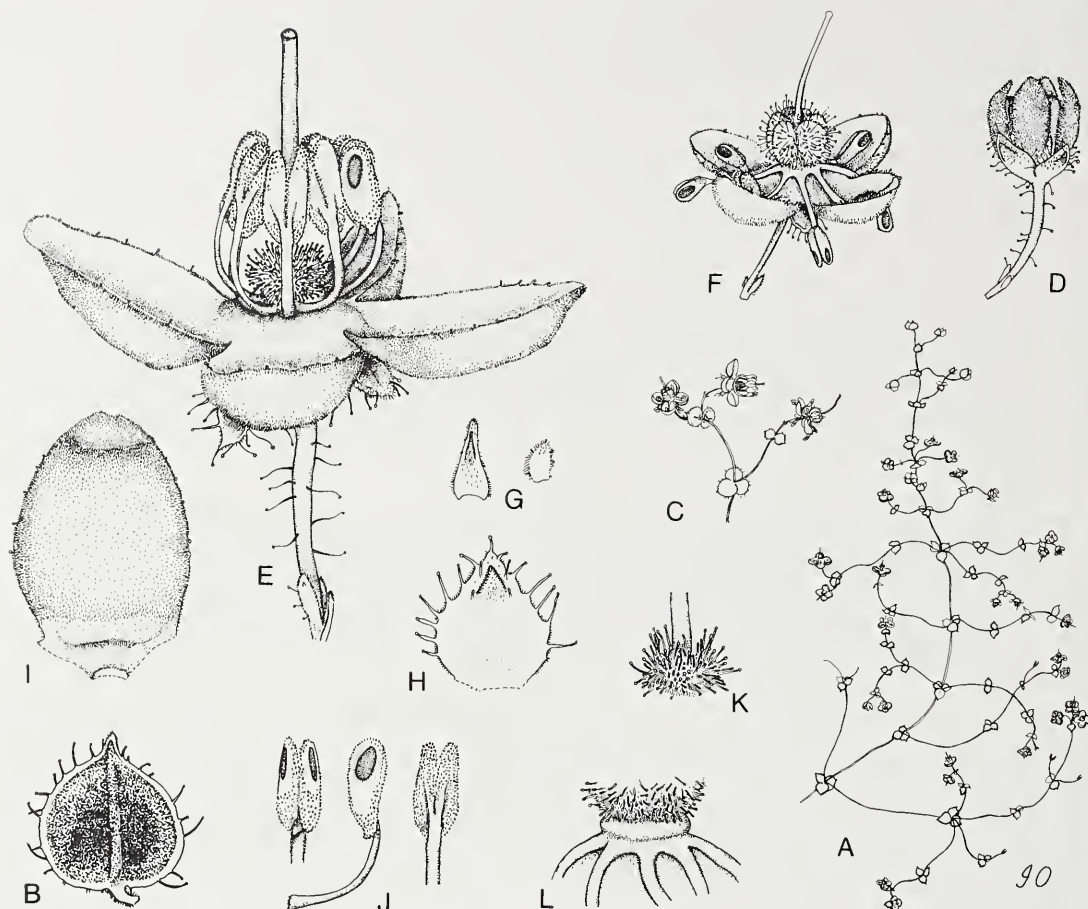


FIGURE 1. — *Erica amicorum*: A, flowering branch, $\times 0,5$; B, leaf, abaxial view, $\times 6$; C, two inflorescences, $\times 1$; D, bud, $\times 6$; E, flower at anthesis, $\times 12,5$; F, older flower with reflexed stamens, $\times 6$; G, bract and bracteole, $\times 12,5$; H, sepal, $\times 12,5$; I, petal, $\times 12,5$; J, anther, front, side & back views, $\times 12,5$; K, ovary, $\times 12,5$; L, base of mature ovary and stamens, $\times 12,5$; all drawn from the type collection, Oliver, Kirsten & Schumann 9054 (STE).

oblong, acute, ciliate and with sessile glands. *Calyx* deeply 4-lobed, lobes almost free, $1,7 \times 1,5$ mm broadly ovate with a sulcate apex, at first erect becoming reflexed, ciliate with fine hairs and short stout glands, pink becoming dark red. *Corolla* deeply 4-lobed, tube 0,8 mm long, very broadly cyathiform, lobes $2,9 \times 2,2$ mm broadly naviculate-elliptic, obtuse to truncate, spreading, becoming reflexed, finely puberulous and finely ciliate and with 5–6 stout short gland-tipped cilia, pink becoming dark red. *Stamens* 8, exserted, at first erect, becoming reflexed into the reflexed corolla lobes, the alternate stamens reflexed over the interstices; filaments 2 mm long, rather thick, subterete, joined into a thick ring at the base, glabrous with a toothed apex; anthers erect, dark brown dorsally attached near the base, thecae 1,2 mm long, obtuse, slightly prognathous or with downwardly pointing sharp base, scabridulous, pore $\pm \frac{1}{3}$ length of the theca, pollen in tetrads. *Ovary* manifest becoming fully exserted, flattened globose, echinoid, covered with short to long glandular hairs with a slight disk below; style exserted, filiform, 2,8–3,2 mm long; stigma simple. *Capsule* globose, glandular setose; seeds ellipsoid to subspherical, reticulate. Figure 1.

This remarkable new species is unlike any other species in the genus on account of having, in the mature flowers,

almost free corolla lobes which are spreading and then reflexed, with the alternate stamens reflexed between these lobes, and an exserted gynoecium. However, the species appears to be allied to species in the section *Ceramia* because of its habit, habitat preference and small pink flowers and open-backed leaves. In particular it superficially resembles species such as *E. oligantha* and *E. planifolia* L., but is different in a number of unique characters.

The possession of almost free corolla lobes is very rare in the subfamily Ericoideae. It occurs in a few schizopetalous cultivars of European heathers. In southern Africa only four species share such a divided corolla, i.e. *Erica lanuginosa* Andr., *E. occulta* E.G.H. Oliver and *E. bodkinii* Guth. & Bol., but not to the same extent as in *E. amicorum*. Also they do not have the lobes reflexed in the mature flowers. This condition renders the flowers unique in that the complete androecium and gynoecium are exserted, thus giving the impression of an erica flower in which the corolla has been eaten away by some insect. The mature flower is also unique in having those stamens alternating with the corolla lobes totally reflexed between the lobes. The stamens are also rather unusual in being joined together at the base into a thickened collar. Fused

or partially fused stamens are now no longer rare in the genus *Erica* because of the recent inclusion of the genus *Philippia* into *Erica* (Oliver 1987, 1988).

Another striking feature of *E. amicum* is the arrangement of the flowers which can be borne in a variety of ways on the branches from simple 1–3-nate terminal florescences to 1-flowered florescences on lateral absolute brachyblasts (Figure 2). These may then all be aggregated together into a loose synflorescence on a lateral branch (Figure 3). When the main branches are long, up to 1 m, they bear numerous lateral branches which themselves bear various combinations of florescences. In some cases the simple 3-flowered terminal florescence can look very similar to a terminal synflorescence. Examination of a florescence will show that flowers alternating with the leaves belong to a simple florescence (Figure 2A) whereas those opposite the leaves are terminal on absolute brachyblasts (Figure 2B).

The species appears to be very restricted in its distribution, occurring only on one mountain complex in the Langeberg range north-east of Riversdale (Figure 4). It is confined to low thick vegetation in moist places alongside streams or in seepage zones. In the type locality it produces matted plants intertwined among other moisture-loving fynbos plants especially tussocks of the restiad, *Platycaulos acutus* Esterhuysen, and therefore the extricating of reasonable flowering branches for herbarium purposes was time-consuming work. One branch disentangled from several restiad clumps was 1,5 m long.

This species is named after my two friends, Dolf Schumann and Gerhard Kirsten, who introduced me to it and with whom the type collection was made.

CAPE.—3321(Ladismith): Romanshoek, 600 m, 8.xii.86 (—CD), Kirsten 1064 (NBG); 1067 (STE); ibid. Schumann 492 (PRE; STE); ibid. Schumann 596 (STE); Langeberg, south slopes, headwaters of Valsrivier, 609 m, 12.xii.1987 (—CD), Oliver, Kirsten & Schumann 9054 (STE & others as per type); Perdeberg Plateau, 975 m, 6.ix.83 (—CD), Viviers 1100 (STE). 3421 (Riversdale): Gavelbos, 307 m, 2.ix.87 (—AB), De Kock sub Bohnen 8811 (STE).

Erica cunoniensis E.G.H. Oliver, sp. nov., in Sectione *Euryloma* *E. squarrosae* Salisb. et *E. gysbertii* Guth. & Bol. affinis sed ab eis floribus patentioribus, id est corolla tubulocampanulata ad anguste cyathiformi non ovoideo-urceolata ad tubuloconica, antheris adhaerentibus propter pilos intertextos laterales non liberis glabris differt.

Fruticulus sparsus erectus ad 300 mm altus. Rami erecti ad extremis foliosi, glabri sterigmatis infrafoliaceis, rami veteres irregulariter porcati cicatibus foliorum notati. Folia 4-nata arcte disposita patentia ad recurva, 2,5–3,5 mm longa, ciliata pilis longis validis ad apice caespitosis seta unica longa atrorubenti terminali; petiolus 1 mm longus appressus complanatus ciliatus. Flores 3–9 verticillati vel secundi ad extremis ramorum; pedicellus 3,5–5,0 mm longus rubens pilis crispis glandulis subsessilibus parvis; bractea 3 × 0,5 mm linearis ad lineari-spathulata, bracteolae bracteis similes sed graciliores. Calyx 4-lobatus, 5 mm longus, lobis longitudine $\frac{3}{4}$ calycis partes aequantibus, dimidio inferiore ovato ciliato glandulis sessilibus dimidio superiore acuto elongato foliato sulcato ciliato pilis longis glandulis sessilibus in parte interiore basi. Corolla 6–9 × 3–4 mm variabilis tubulocampanulata ad anguste cyathiformis viscida atosanguinea; lobis deltoideis longitudine $\frac{1}{6}$ corollae partes aequantibus, erectis ad patentibus ad reflexis. Stamina inclusa; filamenta 5 mm longa apice dilatata et ciliata; anthera adhaerentes propter pilos intertextos, dorsales, thecis anguste ovatis 1,2 mm longis pilis crispis. Ovarium 1,6–2,0 × 1,0–1,2 mm obovoideum plus minusve emarginatum stipite minimo; stylus 6–7 mm longus anguste cylindraceus glaber; stigma plus minusve exserto subcapitato. Fructus anguste obovoideus capsularis stipite parvo; semina subsphaerica papillata. Figura 5.

TYPE.—Cape, Caledon Division, Rooi Els area, Buffelstalberg, ridge running NW from the beacon, 670 m, 5 October 1986, Oliver 8974 (STE, holo.; BM, BOL, E, G, K, MO, NBG, P, PRE, S, W).

Sparse erect woody shrublet up to 300 mm, rarely 500 mm, tall. Branches erect, leafy only towards the ends, glabrous with distinct infrafoliar ridges, bark in older

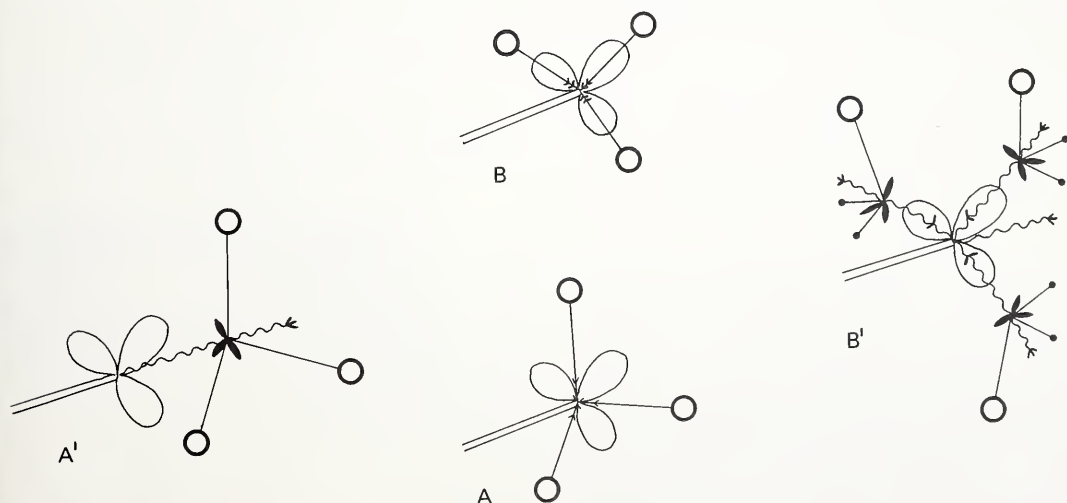


FIGURE 2.—Two similar-looking inflorescences commonly found in *E. amicum*: A, a simple 3-flowered florescence condensed from the schematic diagram A1; B, a compound synflorescence consisting of three 1-flowered florescences (in each florescence there are two aborted flowers) condensed from the schematic diagram in B1. Zigzag lines represent expanded absolute brachyblasts.

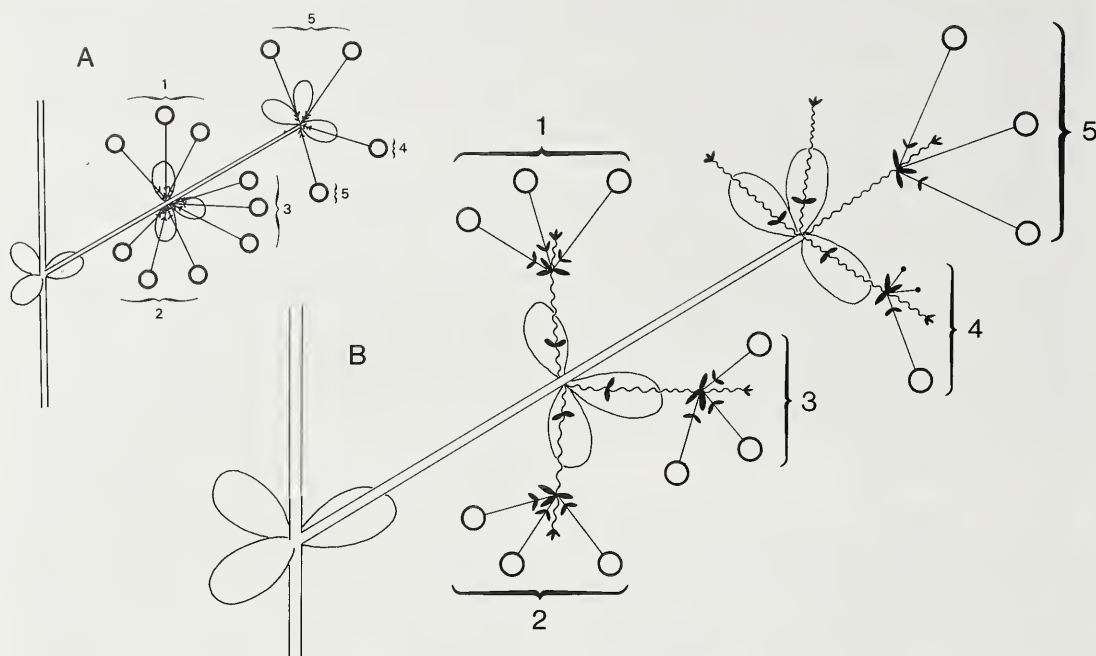


FIGURE 3. —Synflorescence of five florescences on a lateral branch in *E. amicum*: A, the branch as it appears on the plant; B, an enlarged schematic explanation of the branch and five florescences, florescences 1–4 are equal to Figure 2A and florescence 5 to Figure 2B, the apparently single terminal florescence is a synflorescence made up of four flowers from two florescences. Zigzag lines represent expanded absolute brachyblasts.

branches splitting into white infrafoliar flakes, oldest branches red-brown, irregularly ridged with prominent protruding leaf scars. *Leaves* 4-nate, closely arranged, spreading-recurved, 2.5–3.5 mm long, oblong-elliptic, terminated by a long stout dark red seta, ciliate with long stout white hairs tufted towards the apex, setae with puberulous bases; petiole appressed, 1 mm long gradually merging with the lamina, flat, ciliate, occasionally with a few small subsessile glands. *Flowers* in a terminal group of 3–9 at the ends of main branches, either verticillate or secund; pedicel 3.5–5.0 mm long, red with crisped hairs and subsessile small glands; bract 3×0.5 mm, linear to linear-spathulate subbasal; bracteoles like the bract but more slender, median. *Calyx* 4-lobed mostly 5 mm long, lobes $\frac{3}{4}$ the length of the calyx, basal half flat, ovate, and ciliate with sessile marginal glands, upper half acute elongate foliar sulcate and ciliate with long hairs, sessile glands on inner surface of the base otherwise glabrous, green to completely red in dark-coloured flowers. *Corolla* 6–9 \times 3–4 mm variable in shape from tubular-campanulate to narrowly campanulate to narrowly cyathiform, shiny viscid oxblood-red sometimes very darkly so; lobes deltoid, $\frac{1}{6}$ the length of the corolla, erect or spreading to reflexed. *Stamens* included; filaments 5 mm long, considerably dilated at the apex, ciliate in the upper half; anthers remaining in a ring around the style due to interlocking lateral hairs, dorsally attached near the base, thecae 1.2 mm long, narrowly ovate, golden brown with back and filament apex dark red-brown, adaxial hairs colourless, lateral and abaxial hairs reddish. *Ovary* 1.6–2.0 \times 1.0–1.2 mm, obovoid slightly emarginate with a short stipe, glabrous green; style 6–7 mm long, narrowly cylindric, glabrous; stigma just exerted, subcapitate. *Fruit*

a narrowly obovoid capsule with a slight stipe and valves splitting to the base; seeds subspherical, papillate. Figure 5.

This species is similar in overall respects to the species of the Section *Euryloma* which is concentrated in the Caledon District of the south-western Cape. However, it is easily recognizable on account of the open, almost cup-shaped flowers which have a dark red colour like freshly dried oxblood.

E. cunoniensis is known from only a single mountain peak in the far western portion of the Caledon District near Rooi Els. This area is named after the indigenous rooi els tree, *Cunonia capensis* L., hence the specific epithet. On the same mountain there occur two other species in *Euryloma*, *E. gysbertii* and *E. cygnea* Salter. Both these species flower later in the summer and have



FIGURE 4. —Known distribution of *E. amicum*, ●; and *E. cunoniensis*, ★.

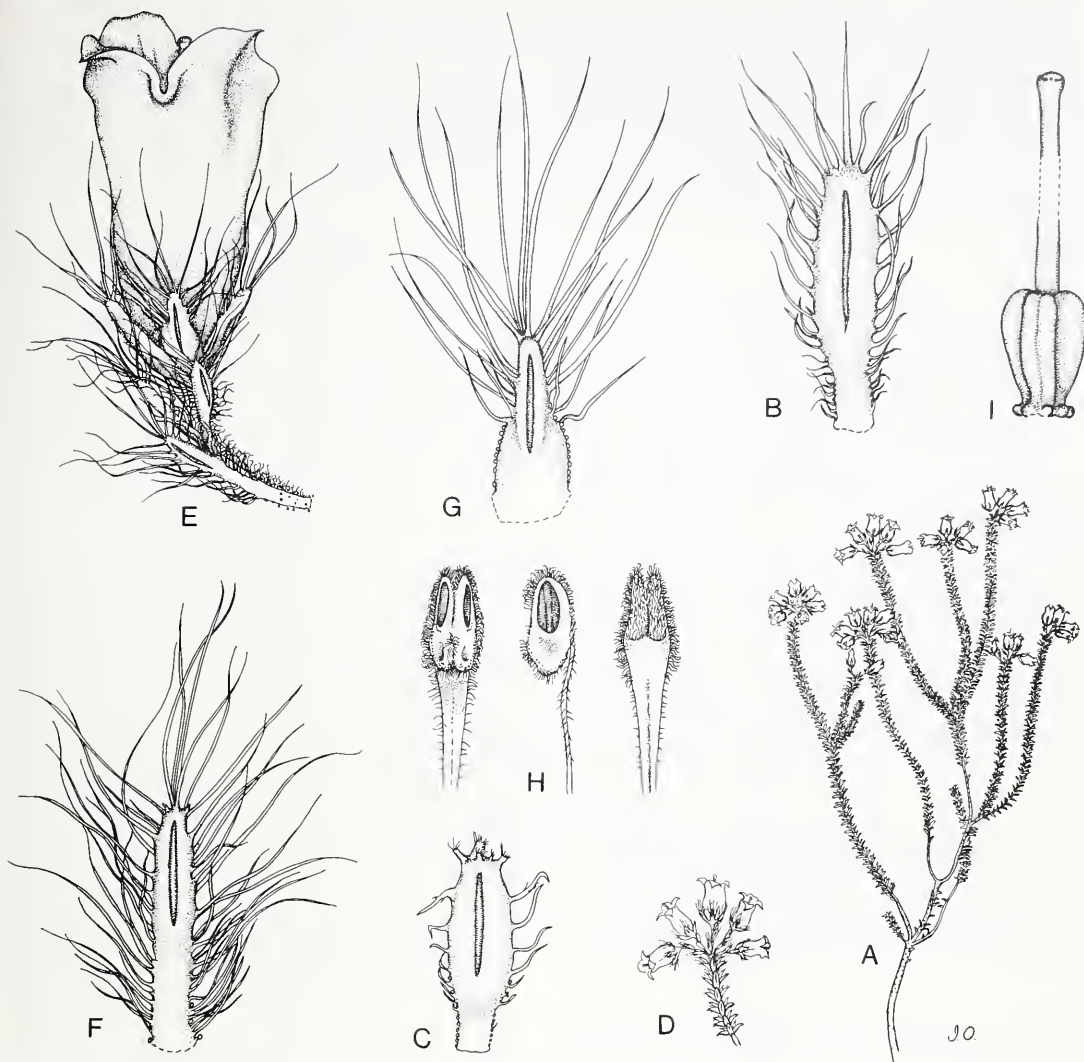


FIGURE 5.—*Erica cunoniensis*: A, flowering branch, $\times 0,5$; B, young leaf from below a florescence, $\times 12,5$; C, old leaf, $\times 12,5$; D, florescence, $\times 1$; E, flower, $\times 12,5$; F, bract, $\times 12,5$; G, sepal, $\times 12,5$; H, anther, front, side & back views, $\times 12,5$; I, gynoecium, $\times 12,5$; all drawn from the type collection, Oliver 8974 (STE).

pale pink, tubular conical flowers with a closed mouth to the corolla. *E. cygnea* is also endemic to Buffelstalberg but is unique in having nodding terminal inflorescences and branches with bends like a swan's neck.

E. cunoniensis also bears some resemblance to material of *E. squarrosa* which does not occur in the same area but further east on the mountains east and north of the Grabouw Basin. Like *E. gysbertii*, *E. squarrosa* has flowers with a closed narrow ovoid-urceolate corolla with spreading lobes. In the latter two species, the basal portion of each flower (pedicel, bract, bracteoles and calyx) is much less hairy than in *E. cunoniensis*. The anthers of *E. cunoniensis* are similar in shape to those of *E. squarrosa*. In contrast to the free glabrous anthers of *E. squarrosa*, however, those of *E. cunoniensis* are united, due to lateral interlocking crisped hairs. *E. gysbertii* has arcuate anthers typical of another group of species in the section. The more open shape of the flowers is also

distinctive and resembles the flowers of *E. lananthera* L. Bol. from the mountains around the mouth of the Palmiet River but this species too has arcuate anthers and very different leaves resembling those of *E. retorta* Montin.

E. cunoniensis was first collected by Thomas Stokoe in 1936. I first saw the species in 1966 as several scattered shrubs on the dry northern slopes of Buffelstalberg. The mountain was visited again in 1969 when a single plant, just past flowering, was all that could be found. At the time it was thought that the plant may have been a hybrid between *E. gysbertii* and *E. massonii* L.f., both common on these slopes but only flowering later in summer. Natural hybrids between very different-looking putative parents have previously been recorded in *Erica* (Oliver 1977, 1986). Lower down the slopes on an earlier occasion I had noted a plant of clearcut hybrid origin between *E. massonii* and *E. cygnea*.

A subsequent search failed to locate any plants of the new species until a concerted effort was made together with members of the A Team of the Botanical Society of South Africa. The plants were eventually found on the southern slopes, thus indicating that the original plants had been chance strays. On the southern side of Buffelstalberg the plants were growing in a single population on a cool moist loamy slope with a south-western aspect. Subsequent examination of the pollen showed it to be normal and well developed.

Material of *E. squarrosa* in the British Museum and Kew, which could form part of the type collection by Masson, is similar to that of *E. gysbertii*, but unlike several collections which have been identified as *E. squarrosa* in Cape herbaria. I refer to this latter material as Species A, which has been collected from the Hottentots Holland Mountains between Landrostkop and the Triplets. It has been recorded as a low compact shrublet with flowers 'brilliant shiny crimson, dark at the throat'. In the flower colour Species A is similar to *E. cunoniensis* but it has globose-urceolate corollas with a very narrow mouth and the anthers are glabrous, free and situated at the mouth of the corolla. This, coupled with the open nature of the flowers and semiconnate anthers, would indicate a totally different pollinator for *E. cunoniensis*. However no pollinators were observed by Rebelo and myself on Buffelstalberg. The pollinator for *E. gysbertii* and *E. squarrosa* is a long-proboscid fly giving the rhino-myiophilous pollination syndrome (Rebelo, Siegfried & Oliver 1985).

E. cunoniensis

CAPE.—3418 (Simonstown): Hazel Peak (?) near Rooi Els, 600 m, x.1950, (—BD), *D.K. Davis SAM 65410* (SAM); Buffelstalberg near Rooi Els, 670 m, x. 1966 (—BD), *Oliver STE 31926* (PRE, STE); ibid. x.1969 (—BD), *Oliver sub Baker 2974* (NBG); ibid. 5.x.1986 (—BD), *Oliver 8974* (BM, BOL, E, G, K, MO, NBG, P, PRE, S, STE, W); ibid. 18.ix.1987, *Schumann 560* (STE); mountains near Rooi Els, 1 066 m, x.1936 (—BD), *Stokoe 6380* (BOL); ibid. *Stokoe SAM 68303* (SAM).

E. squarrosa Salisb. in Transactions of the Linnean Society 6: 380 (1802). Type: Cape, Lange Kloof [?], *Masson s.n.* (possibly BM!).

CAPE.—3419 (Caledon): Emerald Dome (—AA), *Kruger & Haynes 729* (STE); French Hoek Kloof (—AA), *Niven 151* (BOL, K, SAM); Groenlandberg (—AA), *Oliver 4172* (K, STE). Without precise locality: Rivier Zondereinde (?AA), *Masson 40* (BM, BOL, K). Without locality: *Masson s.n.* (BM).

Species A

CAPE.—3418 (Simonstown): Somerset Sneeuokop (—BB), *Brenan 14033A* (K, NBG); *Clarke sub NBG 2506/30* (NBG); *Dyke sub Marloth 4359* (BOL); *Esterhuysen 3613, 3614, 31790* (BOL); *Stokoe 6427* (BOL); *Williams 1155* (K, NBG); Triplets (—BB), *Esterhuysen 8238* (BOL); Landrostkop (—BB), *Stokoe sub SAM 54159* (SAM); *Stokoe sub SAM 55177* (SAM); Valley Berg (—BB), *White sub SAM 12743* (SAM). 3419 (Caledon): Victoria Peak (—AA), *Esterhuysen s.n.* (BOL); *Kerfoot 5737* (STE).

E. gysbertii Guth. & Bol. in Flora capensis 4: 90 (1905). Type: Cape, Stellenbosch Div., on the western foot of the Hottentots Holland Mountains, 200 ft., *Guthrie 3654* (BOL!).

CAPE.—3418 (Simonstown): Somersfontein (—BB), *Boucher 1003* (STE); *Oliver 8996* (STE); Pringle Peak (—BD), *Barker 8506* (NBG, STE); Groot Hangklip (—BD), *Boucher 747* (STE); path to Hangklip

(—BD), *B. Guthrie sub F. Guthrie 3654* (BOL); Buffelstalberg (—BD), *Le Maître 421* (STE); Rooi Els (—BD), *Oliver 96* (STE).

Erica tegetiformis E.G.H. Oliver, stat. et nom. nov., *E. senilis* Klotzsch ex Benth. var. *australis* Dulfer: 32 (1963), non *E. australis* L.: 231 (1771). Type: Cape, Worcester Div., Sonklip, N of Matroosberg, 6500 ft., 17.i.1959, *Esterhuysen 28122* (W, holo!; BOL!, K!, STE!).

Low compact mat-forming shrublet up to 1 m across and 150 mm tall. Branches closely set, mostly prostrate, often partially buried and rooting, with numerous erect branchlets, sparsely and finely puberulous. Leaves 3- or 4-nate, erect, imbricate, 3.4–3.8 mm long, oblong-elliptic obtuse to subacute, sulcate, setose-ciliate with the cilia soon becoming stublike, occasionally with some sessile glands admixed, puberulous all over to almost glabrous; petiole 0.8 mm long, finely and shortly ciliate. Flowers 2–6-nate at the ends of erect lateral mesoblasts; pedicel puberulous, 1.2–2.0 mm long; bract median, 2.5–2.8 mm long, narrowly ovate or ovate-acute, sulcate in the upper $\frac{2}{3}$, with a puberulous base, ciliate with ± 10 long stiff hairs and a longer apical one, white; bracteoles like the bract but narrower, subapproximate. Calyx 4-partite, white; segments 2.7×1.0 mm, erect-spreading, narrowly ovate, subobtusate, sulcate in upper $\frac{3}{4}$, ciliate with ± 12 long stiff hairs. Corolla 4-lobed, oblate-urceolate with 2 invaginations in the basal half, finely puberulous, lobes broadly deltoid, spreading to reflexed. Stamens manifest to partially exserted; filaments 2.3–0.5 mm long, elongate-oblong, narrowed and subsigmoid below the anther, glabrous or villous; anthers dorsally attached near the base, thecae 1.3 mm long, narrowly ovate-oblong, obtuse, hairy in front sometimes with a few lateral hairs, basally crested, crests short, broad, fimbriate, pore $\frac{2}{3}$ – $\frac{3}{4}$ the length of the theca. Ovary 1.1×1.3 mm, crown-shaped, 8-ridged, emarginate, puberulous sometimes above only; style 4 mm long reducing in thickness upwards, glabrous; stigma exserted, subcapitellate. Fruit shortly subcylindric; capsule sparsely puberulous; seeds 0.8 mm long, irregularly ellipsoid, reticulate. Figure 6.

The unspecialized inflorescence, dense mat-forming habit, globose urceolate flowers with lanceolate sepals and distinctly visible corolla and the dark brown anthers serve to distinguish *E. tegetiformis*.

This taxon was originally described by Dulfer (1964) as a variety of the Cedarberg species, *E. senilis* Klotzsch ex Benth., based on the single collection of *Esterhuysen 28122* from Sonklip near Matroosberg. However, material recently collected and sent to me for identification, looked so different from *E. senilis* that I did not link the material with that species at the time and regarded it as a distinct undescribed species. Only when checking on possible alliances within the Section *Chromostegia*, particularly *E. senilis* and *E. eriophoros* Guth. & Bol. did I realise that Dulfer's variety was in fact this new species and that it bears only a superficial resemblance to *E. senilis*.

E. tegetiformis undoubtedly belongs in the Section *Chromostegia* because of the prostrate habit and the compact heads of flowers even though in the new species this latter character is not very pronounced as is the case in *E. senilis* in which the leaves below the inflorescence as well as the bract and bracteoles, are enlarged and coloured giving an involucre appearance to the inflorescence. This feature is

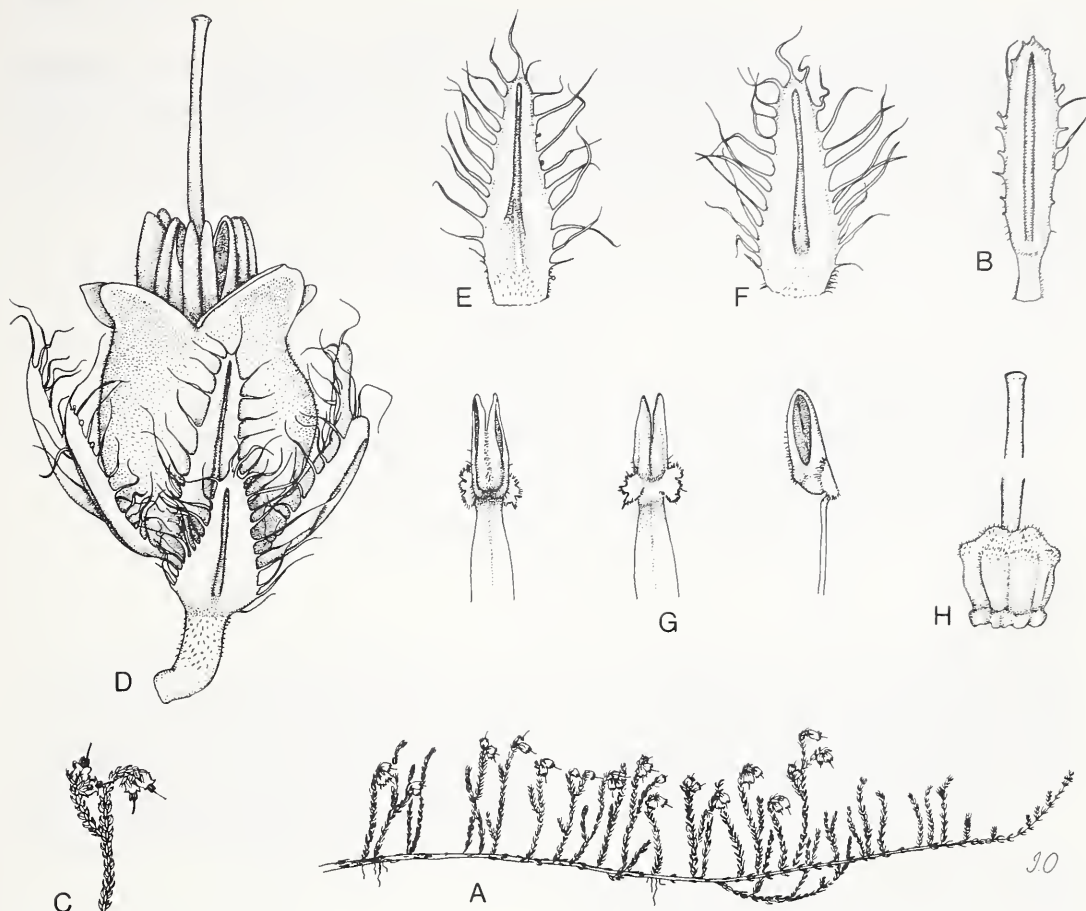


FIGURE 6. — *Erica tegetiformis*: A, flowering branch, $\times 0,5$; B, leaf, $\times 12,5$; C, two florescences, $\times 1$; D, flower, $\times 12,5$; E, bract, $\times 12,5$; F, sepal, $\times 12,5$; G, anther, front, side & back views, $\times 12,5$; H, gynoecium, $\times 12,5$; all drawn from Oliver 9074 (STE).

far less developed in *E. eriophoros* and hardly so in *E. tegetiformis*. Table 1 lists the characters showing differences between the three species. Similarities with *E. senilis* are not close, perhaps only in the relative size and shape of the anther. There is more affinity with *E. eriophoros*, but this in turn shows a closer affinity with *E. senilis* in many characters.

Populations of this species were visited on Rocklands Peak north of Ceres. Here the plants were growing among very short restiads on open dry stony slopes at an altitude of 1 440 m. At this altitude the plants must be subjected to considerable cold in winter and even a heavy covering of snow. In this regard they were effectively adapted by being very low-growing and forming extensive compact mats, hence the specific epithet. The long prostrate branches frequently produce adventitious roots at intervals along their length. From other collections the notes give some indication of the habit and habitat: *Stokoe 4518*—'straggling over sq. yds of bare ground'; *Esterhuysen 24328*—'rocky summit, sprawling amongst rocks'; *Esterhuysen 29853*—'trailing in habit sometimes colonizing after a fire'. Figure 7.

E. senilis, which occurs to the north, does not produce dense mats. It has prostrate as well as erect branches

forming a spreading shrub up to 300 mm tall and grows in amongst denser ericoid/restioid vegetation. *E. eriophoros* is rather rare. Until recently it was known only from the type collection made at the end of last century on Gydoberg in the southern Cold Bokkeveld. Recent collections were made on Gideonskop in the southern Cedarberg. From these few collections it is difficult to assess the habit of the species. Plants growing in the National Botanical Garden, Kirstenbosch, were originally small, compact and erect, but have begun to form lateral creeping branches. Mr Kotze, horticulturist at Kirstenbosch, informs me that the plants on Gideonskop were prostrate and mat-forming on a sandy open plateau.

E. tegetiformis appears to grow at slightly higher altitudes and occurs south of the other two species, hence Dulfer's choice of epithet, which cannot now be adopted at species level because of the European species, *E. australis* L. The locality from Naudesberg in the westernmost part of the Langeberg range is somewhat unusual for species associated with the Cedarberg/Bokkeveld region.

CAPE.—3319 (Worcester): Rocklands Peak, vi.1955 (—AB), *Esterhuysen 24328* (BOL); *ibid.*, 1 440 m, 19.xii.1987 (—AB), *Oliver 9074* (BM, BOL, K, MO, NBG, PRE, STE); Baviaansberg, 2.i.1942 (—BA), *Compton 12838* (BOL); *ibid.*, 1 676 m, 4.xi.1962, *Esterhuysen*

TABLE 1.—Characters distinguishing between *Erica senilis*, *E. eriophoros* and *E. tegetiformis*

	<i>E. senilis</i>	<i>E. eriophoros</i>	<i>E. tegetiformis</i>
Leaves	densely setose ciliate puberulous abaxially setae straight	densely setose ciliate puberulous abaxially setae crisped	sparsely setose ciliate marginal only setae crisped
Floral leaves, bract, bracteoles	much enlarged white not forming an involucre	slightly enlarged white not forming an involucre	very slightly enlarged whitish not forming an involucre
Calyx	linear spatulate setae all over setae straight	linear subspathulate setae all over setae mostly crisped	lanceolate setae marginal setae crisped
Corolla	broad cyathiform not visible lobed ² / ₃ copiously ciliate	cyathiform visible lobed ¹ / ₄ sparsely ciliate	globose urceolate visible lobed ¹ / ₄ eciliate
Anthers	white pore large, ³ / ₄ of the theca large crests	pale brown pore small, ¹ / ₅ of the theca very small awns	dark brown pore large, ³ / ₄ of the theca small crests
Ovary	glandular	glandular	eglandular

29853 (BOL, K); *ibid.*, i.1937, *Stokoe 4518* (BOL); *ibid.*, 1 828 m, 12.i.1956, *Stokoe in SAM 68303* (BOL, SAM, STE); Sonklip, north of Matroosberg, 1 980 m, 17.i.1959 (–BC), *Esterhuysen 28122* (BOL, K, STE, W); Conical Peak, xii.1940 (–BC), *Stokoe 7832* (BOL); *ibid.* i.1941, *Stokoe SAM 55290* (SAM); Naudesberg, 13.xi.80 (–DB), *Van Jaarsveld & Bean 5819* (BOL, NBG, PRE, STE).

E. senilis Klotzsch ex Benth. in DC., *Prodromus* 7: 617 (1839); Guth. & Bol.: 235 (1905). Type: Cape, Cederbergen, *Drège 2966* (B†, holo.!: K!, SAM!, W!).

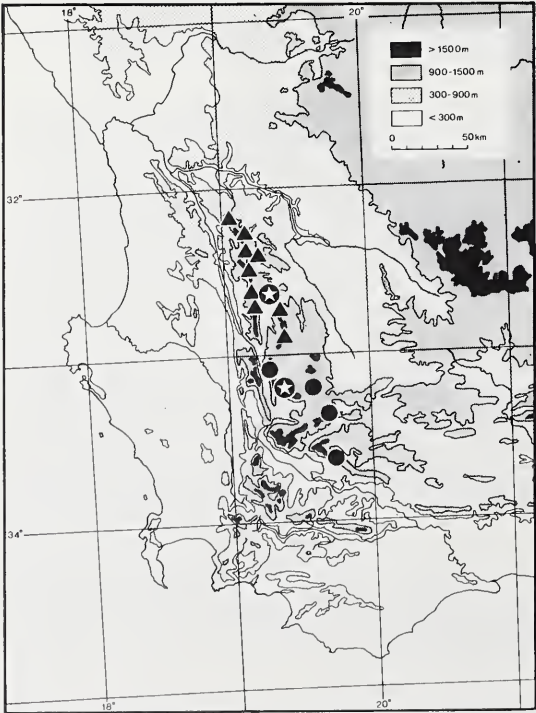


FIGURE 7.—Known distribution of *E. tegetiformis*, ●; *E. senilis*, ▲; and *E. eriophoros*, ●•.

CAPE.—3219 (Wuppertal): Sneekop (–AA), *Bolus 8627* (BOL, STE); Heuningvlei (–AA), *Emdon 146* (K, STE); Krakadouw (–AA), *Pocock 498, 593* (STE); Heuningvlei (–AA), *Taylor 8548, 10475* (STE); Hoogvertoon (–AC), *Forsyth 39* (STE); Wolffberg to Gabriel's Pass (–AC), *Kruger 926* (STE); Sneeuwig (–AC), *Pocock 401* (STE); *Taylor 6163* (STE); Middelberg Pass (–CA), *Oliver 4016* (STE); Gideonskop (–CB), *Rourke 664* (NBG, STE); Bloukop (–CB), *Williams 2123* (NBG, STE); Tweefontein (–CC), *Schlechter 10129* (BM, BOL, K); Heiveld in Cold Bokkeveld (–CD), *Hanekom 1212* (STE); Cederberg, without precise locality, *Drège 2966* (K, SAM).

E. eriophoros Guth. & Bol. in *Flora capensis* 4: 234 (1905). Type: Cape, Ceres Div., Gydouw Mountain in Cold Bokkeveld, 6000 ft, *Schlechter 10240* (BOL, holo.!: K!, PRE!, SAM!).

CAPE.—3219 (Wuppertal): Gideonskop (–CB), *Williams 990* (NBG); *ibid.* *Kotze 787* (hort. NBG). 3319 (Worcester): Gydouw (–AB), *Schlechter 10240* (BOL, K, SAM).

REFERENCES

DULFER, H. 1964. Revision der südafrikanischen Arten der Gattung *Erica* L. 2. *Annalen des Naturhistorischen Museums Wien* 68: 25–177.

GUTHRIE, F. & BOLUS, H. 1905. *Erica*. In W.T. Thistleton-Dyer, *Flora capensis* 4,1: 2–315.

LINNAEUS, C. 1771. *Mantissa plantarum altera*: 229–236. Stockholm.

OLIVER, E.G.H. 1977. The identity of *Erica flavisepala*. *Bothalia* 12: 195–197.

OLIVER, E.G.H. 1986. The identity of *Erica vinacea* and notes on hybridization in *Erica*. *Bothalia* 16: 35–38.

OLIVER, E.G.H. 1987. Studies in the Ericoideae (Ericaceae). VII. The placing of the genus *Philippia* into synonymy under *Erica*; the southern African species. *South African Journal of Botany* 53: 455–458.

OLIVER, E.G.H. 1988. Studies in the Ericoideae (Ericaceae). VI. The generic relationship between *Erica* and *Philippia* in southern Africa. *Bothalia* 18: 1–10.

REBELQ, A.G., SIEGFRIED, W.R. & OLIVER, E.G.H. 1985. Pollination syndromes of *Erica* species in the south-western Cape. *South African Journal of Botany* 51: 270–280.

Studies in the southern African species of *Justicia* and *Siphonoglossa* (Acanthaceae): seeds

K.L. IMMELMAN*

Keywords: Acanthaceae, *Justicia*, seeds, *Siphonoglossa*, South Africa, taxonomy

ABSTRACT

The seeds of all species of *Justicia* (except *J. thymifolia* (Nees) C.B. Cl.) and *Siphonoglossa* in the southern African region (as defined by the *Flora of southern Africa*) were examined with the Scanning Electron Microscope. A wide range of different seed surfaces were seen, many of which could be correlated with other characters to further reinforce grouping of species into sections. However, some species that on other characters, would be placed together, had widely differing seed tests. Gross surface morphology varied from smooth to colliculate, irregularly rugose, reticulate with the ridges variously arranged, wheel-shaped (radiate or ammonite-like), with a central ridge or with multicellular barbed scales. The seeds were without hairs, unlike some American species sometimes considered to belong in *Justicia* (Graham 1989). Micromorphology also provided useful characters, with seeds being reticulate, papillate, minutely or deeply rugose or with one to many crystals visible. Critical-point drying was sometimes helpful in viewing microstructure.

UITTREKSEL

Die sade van al die *Justicia*- en *Siphonoglossa*-spesies (behalwe *J. thymifolia* (Nees) C.B. Cl.) in die Suider-Afrikastreek (soos deur die *Flora of southern Africa* omskryf) is met die aftaselektronmikroskoop bestudeer. 'n Wye reeks verskillende saadopervlakke is waargeneem, waarvan baie met ander kenmerke gekorreleer kon word om die groepering van spesies in seksies verder te ondersteun. Sommige spesies wat op grond van ander kenmerke saam gegroepeer sou word, het egter uiteenlopend verskillende saadtestas gehad. Makro-oppervlakmorfologie het varieer vanaf glad tot knoppig, onreëlmatig rimpelig, netvormig met die riuwe op verskeie maniere gerangskik, wielvormig (straalvormig of ammonietvormig), met 'n sentrale rif of met meersellige stekelskubbe. Die sade was sonder hare, anders as by sommige Amerikaanse spesies wat soms as lede van *Justicia* beskou word (Graham 1989). Mikromorfologie het ook nuttige kenmerke opgelewer, met sade wat netvormig, gepapilleer, fyn of diep rimpelig was of met een tot baie kristalle sigbaar. Kriteke-punt-droging was soms nuttig by waarneming van mikrostruktuur.

INTRODUCTION

Very few SEM investigations of the seed surfaces of African members of the Acanthaceae have so far been carried out. Those with relevance to the present study are briefly reported on below.

Munday (1980), in revising the southern African species of *Monechma* (Justiciae), found that, although all seeds had a smooth testa, there was variation in their size, shape and colour. A longitudinal ridge was characteristic of one species [*M. desertorum* (Engl.) C.B.Cl.] and mottled colouring of another [*M. spartioides* (T. Anders.) C.B.Cl.].

In his paper on *Anisotes* (also Justiciae) Baden (1981b) found that the seeds often had a longitudinal ridge, and he described the texture as rugose, tuberculate, verrucose or smooth. In one species (*A. guineensis* Lindau) the seeds were glandular. This species was unusual in other ways also, such as having 4-porate pollen, and was placed by Baden in a separate monospecific section.

Balkwill & Getliffe Norris (1984) used the fact that the seed surface in *Hypoestes* was asperous, tuberculate or smooth in their key to species.

Balkwill, Getliffe Norris & Schoonraad (1986) used the microsculpturing of the seed surface in their investigation of *Peristrophe* and concluded that its value at present was

mainly at species level. The testa of the species of the genus was basically reticulate with minute papillae, and may or may not have tubercles bearing one, two or three layers of recoiled hooks. Details of the tubercle surface were also used.

Hedré (1987) in his revision of *Justicia capensis* Thunb. and its tropical African allies, described the seed surface only as 'tuberculate' and did not use it to distinguish species. In his paper on the *Justicia mollugo* group in tropical Africa (1988), he described the seeds of most of the species dealt with, but did not use them in his key.

Balkwill & Getliffe Norris (1988) re-appraised tribal and subtribal limits within the Acanthaceae of southern Africa, and considered the lack of hairs on the seed coat to be definitive of Justiciae and some genera of Acanthoideae. However, Graham (1989) included species of *Justicia* with a variety of hair types, some even being tested by her and found to be hygroscopic (in her sect. *Anisostachya*). Graham's delimitation of *Justicia* was very wide, including a number of previously segregate genera, and she described some 20 seed types. In sect. *Sarotheca* some species had seeds with hairs having recoiled barbs similar to those seen by Balkwill *et al.* (1986) in *Peristrophe*. In sect. *Vasica* some of the Old World species had smooth testas, a character usually considered characteristic of *Monechma*, which she accepted as a distinct genus.

METHODS

Seeds of each species and subspecies of *Justicia* in southern Africa (except *J. thymifolia*), as well as *Siphono-*

* National Botanical Institute/Department of Agricultural Development, Private Bag X101, Pretoria 0001.
MS. received: 1989.06.15.

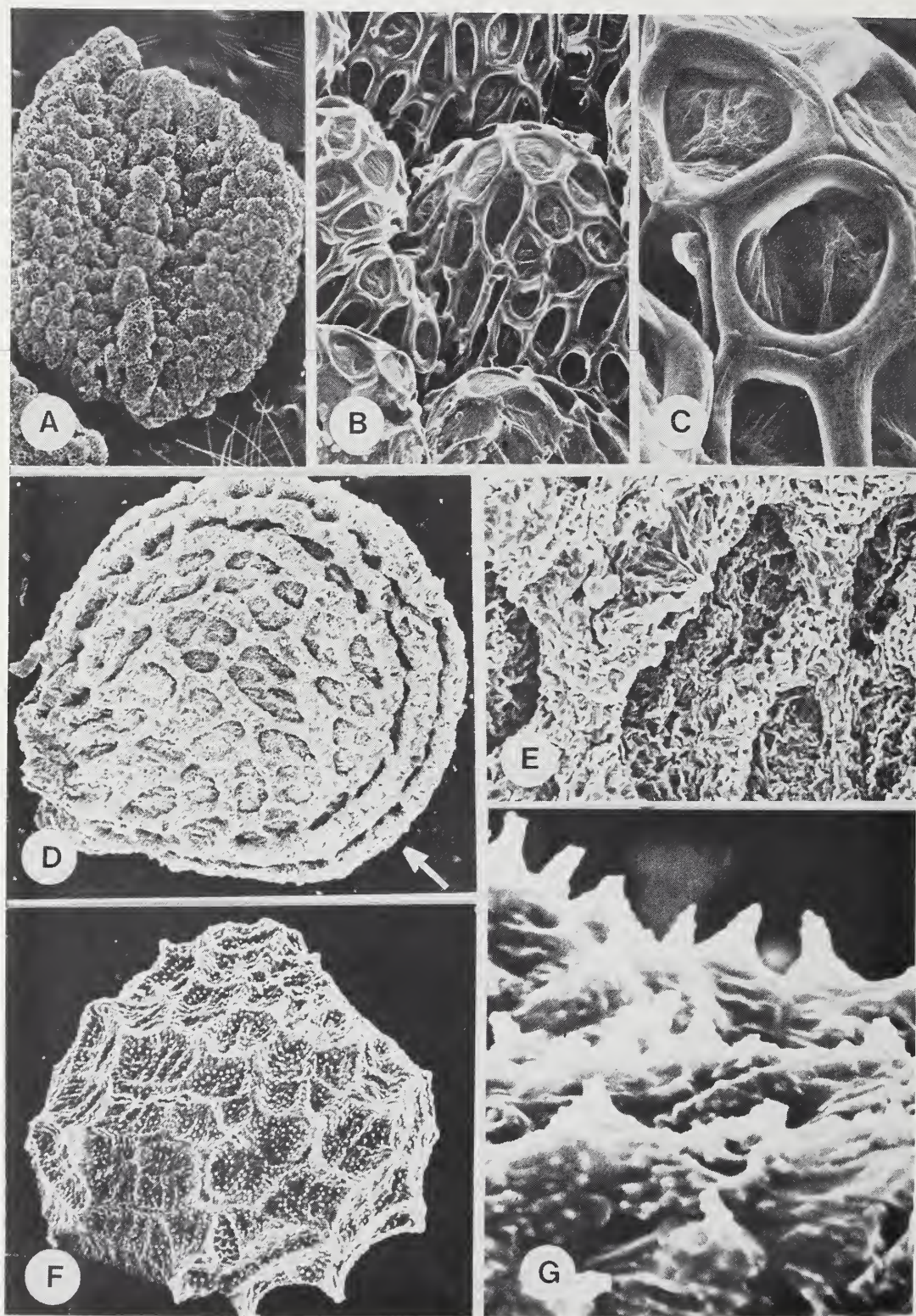


FIGURE 1. — *Justicia* sect. *Harnieria* p.p.: A–C, *J. capensis*: A, whole seed, × 30; B, detail of seed, × 360; C, whole seed, × 1200. *Justicia* sect. *Rostellularia* subsect. *Ansellia*: D–G, D, E, *J. crassiradix*: D, whole seed, arrow indicates semicircular marginal ridges, × 70; E, detail of seed, × 360. F, G, *J. anselliana*: F, whole seed (critical-point dried), × 70; G, detail of seed (critical-point dried), × 1600.

glossa leptantha subsp. *leptantha* and *Monechma mollissimum*, were examined. Taxa covered in this study all occur in southern Africa as defined by the *Flora of southern Africa*, i.e. the area south of the Cunene and Limpopo Rivers. Seeds of each were removed from herbarium sheets and mounted directly onto 15 mm aluminium stubs for viewing under the SEM. Two to six seeds per taxon were viewed depending on the size of the seeds.

Where fresh fruiting material was available from the nursery (National Botanical Institute, Pretoria), seeds were also dehydrated, fixed and critical-point dried by the following method:

- 1, specimens were dehydrated either in series of ascending concentrations of alcohol or, more usually, in two changes of 2,2-Dimethoxypropane (DMP) for up to two hours;
- 2, they were then transferred to 100% acetone for five minutes;
- 3, critical point drying was done with liquid CO₂ evaporated off at 40°C and 80–90 atmospheres (critical point for CO₂ is at 31,3°C and 72,8 atmos.);
- 4, the dried specimens were stored in a desiccator with silica gel, or immediately mounted on aluminium stubs for coating.

All seeds were glow-discharge coated with metallic gold in an Eiko sputter coater. They were then viewed with an MSM 4 Hitachi-Akashi (desk top model) SEM at kv 15 and photographed.

Delimitation and names of sections are according to Graham (1989).

RESULTS AND DISCUSSION

Results of critical-point drying: it was noted in many instances that material that had not been critical-point dried showed structures of the testa such as radial cell walls, ornamentation of these walls, and crystals in the testa, better than fresh, critical-point dried material. This was due to the collapse of the outermost cell walls, which made it easier to see underlying structures. On the other hand, structures such as fine papillae were sometimes only visible when the material had been pre-treated before viewing. This was the case with *J. anselliana* (Nees) T. Anders. (Figure 1G), and it was felt that critical-point drying would be a valuable procedure for those species which, like *J. anselliana*, had 'amorphous' testas, as found in sects. *Ansellia* and *Justicia* p.p.

A wide variety of seed surface types was seen, sometimes peculiar to the species, but in at least some cases correlating with characters used to demarcate sections.

Sect. *Rostellularia* subsect. *Ansellia* p.p. (*J. crassiradix* Burkill & Clarke, *J. anselliana* (Nees) T. Anders., *J. anagaloides* (Nees) T. Anders.): in *J. crassiradix* the seed has a gross pattern of reticulate ridges and depressions on the sides, whereas around the margin of the seeds the ridges form a roughly semicircular pattern (Figure 1D, arrowed). The testa of two other southern African species, *J. anselliana* (Figure 1F) and *J. anagaloides*, which on

the basis of other characters should probably be placed with *J. crassiradix* in subsect. *Ansellia*, do not show this semicircular pattern. Instead, the ridges are randomly placed on the seed surface. At higher magnifications, when they were viewed without having been critical-point dried, the seeds of all three species had an irregularly rugose surface (Figure 1E). When seed of *J. anselliana* was critical-point dried, the cells in the depressions between the ridges were found to each have a centrally situated papilla (Figure 1G), while the cells on the ridge were without papillae, having instead a minutely verrucose surface. The papillae were longer than wide, with an acute or truncate apex. It was not possible to establish whether these papillae were present in the other two species, as fresh material was not available.

Sect. *Justicia* p.p. (*J. orchioides* L.f., *J. cuneata* Thunb., *J. guerkeana* Schinz, *J. platysepalae* (S. Moore) P.G. Mey., *J. thymifolia* (Nees) C.B. Cl.): rugose testas are also present in all examined species of Sect. *Justicia* except *J. bolusii* C.B. Cl. (Figure 2A, B). Only the first four species could be examined, as seeds of *J. thymifolia* were not available. This irregularly rugose pattern is apparent at both low and high magnifications. Seeds of *J. guerkeana* were also critical-point dried for viewing. In this case, unlike *J. anselliana*, the irregularly rugose pattern remained, and no papillae were seen.

Sect. *Justicia* p.p. (*J. bolusii* C.B. Cl.): this species (Figure 2C, D), which on other characters might be considered to occupy an isolated position among the southern African species of the genus, also has very atypical seeds. These are almost smooth, being only very slightly rugose even at high magnifications (Figure 2D) and compare well with *Monechma mollissimum* (Nees) P.G. Mey., which was also viewed for purposes of comparison (Figure 2E, F). However, it was decided that, despite similarities in the seeds and capsules, *J. bolusii* could not be transferred to *Monechma*. It differs from *Monechma* in its 'spicate' inflorescence and its tricolporate pollen with entire margocolpi (Immelman 1989).

Sects. *Raphidospora* p.p. (*J. campylostemon* (Nees) T. Anders.), *Tyloglossa* p.p. (*J. flava* (Vahl) Vahl, *J. kirkiana* T. Anders.), *Rostellularia* subsect. *Ansellia* p.p. (*J. minima* A. Meeuse) and *Harnieria* p.p. (*J. capensis* Thunb.): seeds of a number of species of *Justicia* from various sections of the genus (listed above) are basically colliculate or rugose with slightly protruding radial cell walls forming a reticulate surface pattern. However, if other characters of the species are taken into consideration, they are not necessarily related, and there are also many differences in detail in both the macro- and micro-patterns. *J. capensis* (Figure 1A–C) and *J. minima* (Figure 3A–C) have a randomly colliculate macro-pattern and, at high magnifications, show a simple reticulate micro-pattern. *J. campylostemon* (Figure 4A–C) has an irregularly vermiculate macro-pattern, and the radial cell walls are ornamented with a double row of minute projections, which are more clearly visible without critical-point drying (Figure 4C). *J. flava*, *J. kirkiana*, and *J. petiolaris* have characteristic macro-patterns (see below) and crystals visible in the testa.

Sect. *Tyloglossa* (*J. flava* (Vahl) Vahl, *J. kirkiana* T. Anders. and *J. petiolaris* (Nees) T. Anders.): these three

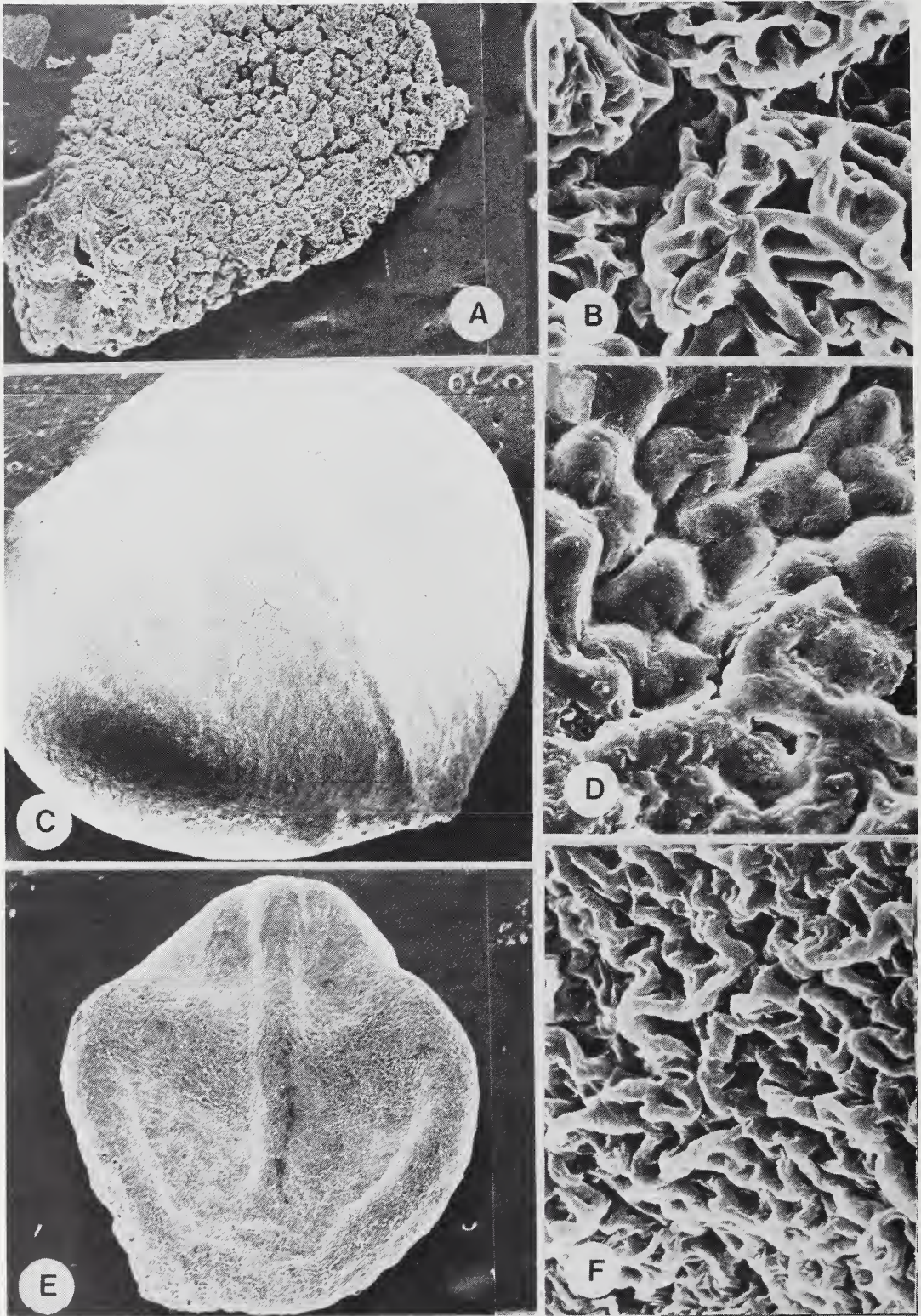


FIGURE 2.—*Justicia* sect. *Justicia*: A–D. A, B, *J. orchyioides*: A, whole seed, $\times 55$; B, detail of seed, $\times 1900$. C, D, *J. bolusii*: C, whole seed (composite figure), $\times 25$; D, detail of seed, $\times 1800$. E, F, *Monechma mollissimum*: E, whole seed, $\times 60$; F, detail of seed, $\times 2300$.

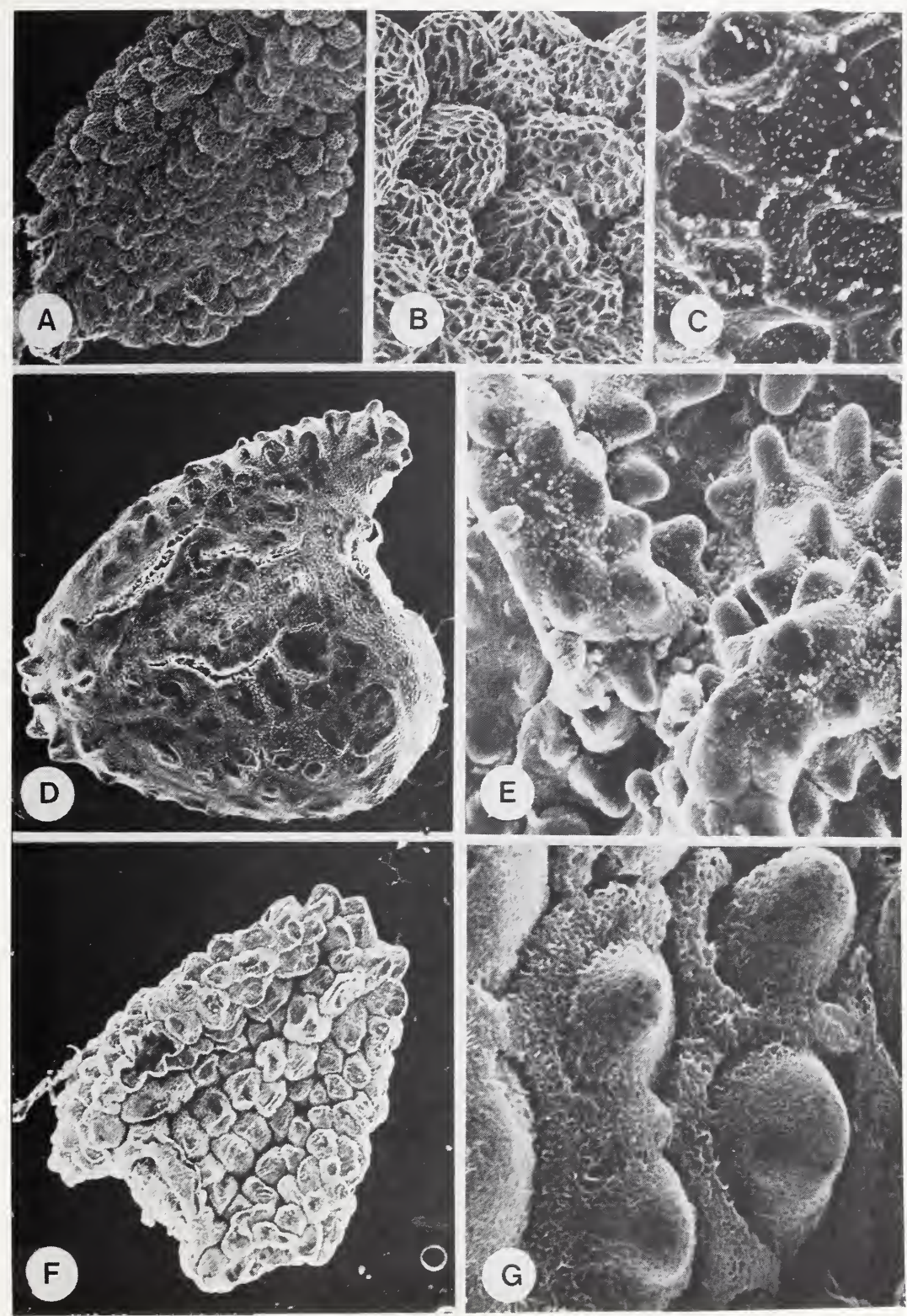


FIGURE 3. —A–C, *Justicia minima*: A, whole seed, $\times 50$; B, detail of seed, $\times 200$; C, detail of seed, $\times 1200$. *Justicia* sect. *Harnieria* p.p.: D–G. D, E, *J. protracta* subsp. *protracta*: D, whole seed, $\times 50$; E, detail of seed, $\times 1400$. F, G, *J. parvibracteata*: F, whole seed, $\times 70$; G, detail of seed, $\times 3500$.

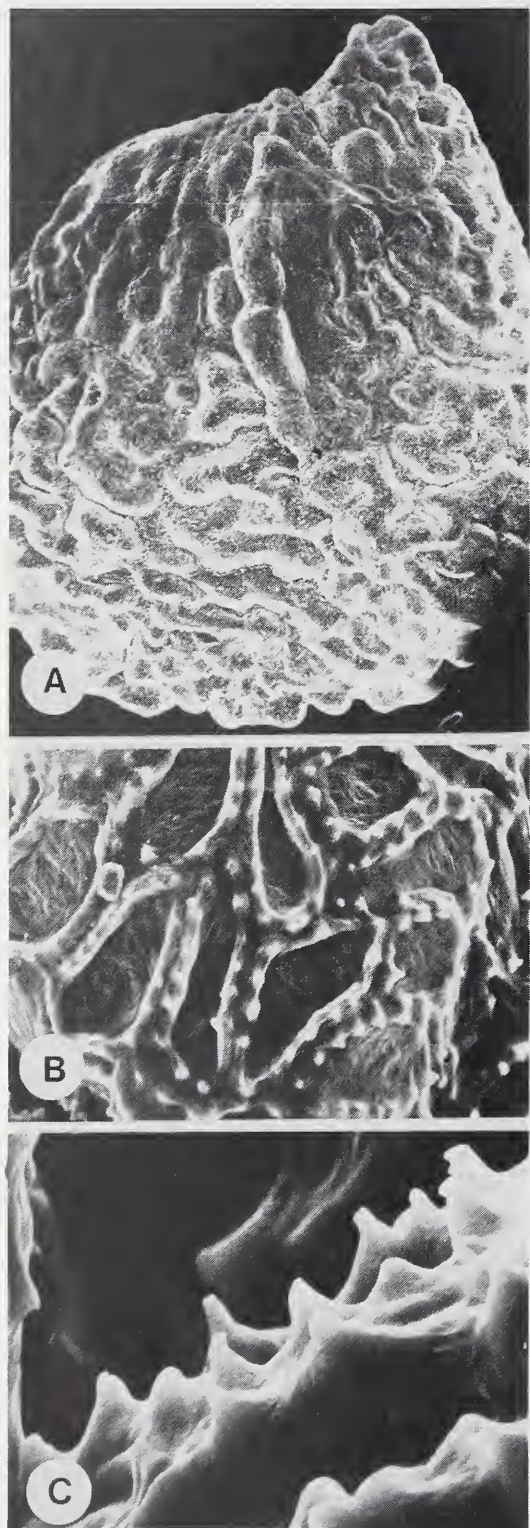


FIGURE 4.—*Justicia* sect. *Raphidospora*: A–C, *J. campylostemon*: A, whole seed (composite picture), $\times 32$; B, detail of seed, $\times 725$; C, detail of seed, $\times 3000$.

species (Figure 5) form a well-defined section. They all have a characteristic reticulate micro-pattern on the seed surface and one large or many small crystals visible as cubic or rectangular projections below the surface of the outer wall (Figure 5B, D, F). Such crystals were not seen in any other *Justicia* species examined. These crystals are scarcely visible in critical-point dried material, but are clearly seen when the material is viewed without pre-treatment. The two yellow-flowered species (*J. flava* and *J. kirkiana*) have a highly characteristic macro-pattern of raised segments or bosses (colliculae) (Figure 5C, E), termed 'ammonite-like' by Graham (1989), but which could also be interpreted as three segmented rows or as segments radiating from a central 'hub' like spokes of a wheel. This pattern is not present in any of the subspecies of the blue-flowered *J. petiolaris*, where the gross pattern of the testa is sometimes colliculate, and sometimes rather irregularly rugose, often having a central longitudinal ridge.

Sect. **Betonica** (*J. betonica* L. and *J. montis-salinorum* A. Meeuse): both these species have a macro-pattern of short sinuous ruminant ridges (Figure 6). The ridges are often drawn out into dentate structures which either have an areolate micro-pattern on their surface, as in *J. betonica* (Figure 6B) or they are irregularly striate as in *J. montis-salinorum* (Figure 6D). When broken, these teeth can be seen to be hollow.

Sect. **Raphidospora** p.p. (*J. glabra* Koenig ex Roxb.): the most complex pattern observed was that of *J. glabra*, which has seeds quite unlike those of any other *Justicia* species (Figure 7A–E). It is probable, on the basis of inflorescence and pollen characters, that it should be grouped with *J. campylostemon*, in sect. *Raphidospora*, but the seed testas of the two species are quite different. The testa of *J. glabra* is drawn out into numerous long flat multicellular scales (Figure 7B) with each cell of the scale producing a sharp retrorse barb (Figure 7C–E). The scales are probably a means of seed dispersal, analogous to the barbed scales on the fruit of *Bidens pilosa* (Asteraceae). *J. campylostemon*, on the other hand, has the seeds covered with irregular vermiculate ridges, each of which has a reticulate micro-pattern on the surface. Along each margin of the raised ridges of the reticulations there is a row of small, blunt, tooth-like projections (Figure 4B, C).

Sect. **Harnieria** p.p. (*J. protracta* (Nees) T. Anders., *J. odora* (Forssk.) Vahl, *J. parvibracteata* Immelman, *J. dinteri* S. Moore) as well as *Siphonoglossa leptantha* (Nees) Immelman subsp. *leptantha*: these species have a colliculate macro-pattern. They also share a micro-pattern where each cell is defined with a single large rounded papilla in the centre of each cell (Figures 3D–G; 8). These papillae are visible in material that was not pre-treated before mounting, as well as in critical-point dried material of *S. leptantha* subsp. *leptantha* (Figure 8A). Material of *Siphonoglossa* viewed without pre-treatment had an irregularly rugose testa.

In *J. dinteri* two kinds of capsule are regularly produced, a four-seeded normal capsule and a one-seeded smaller capsule with four irregularly toothed wings. The seeds from each type of capsule were compared, and the testa found to be similar, though the seeds in the one-seeded capsules were larger (Figure 8B, D, F, cf. Figure 8C, E).

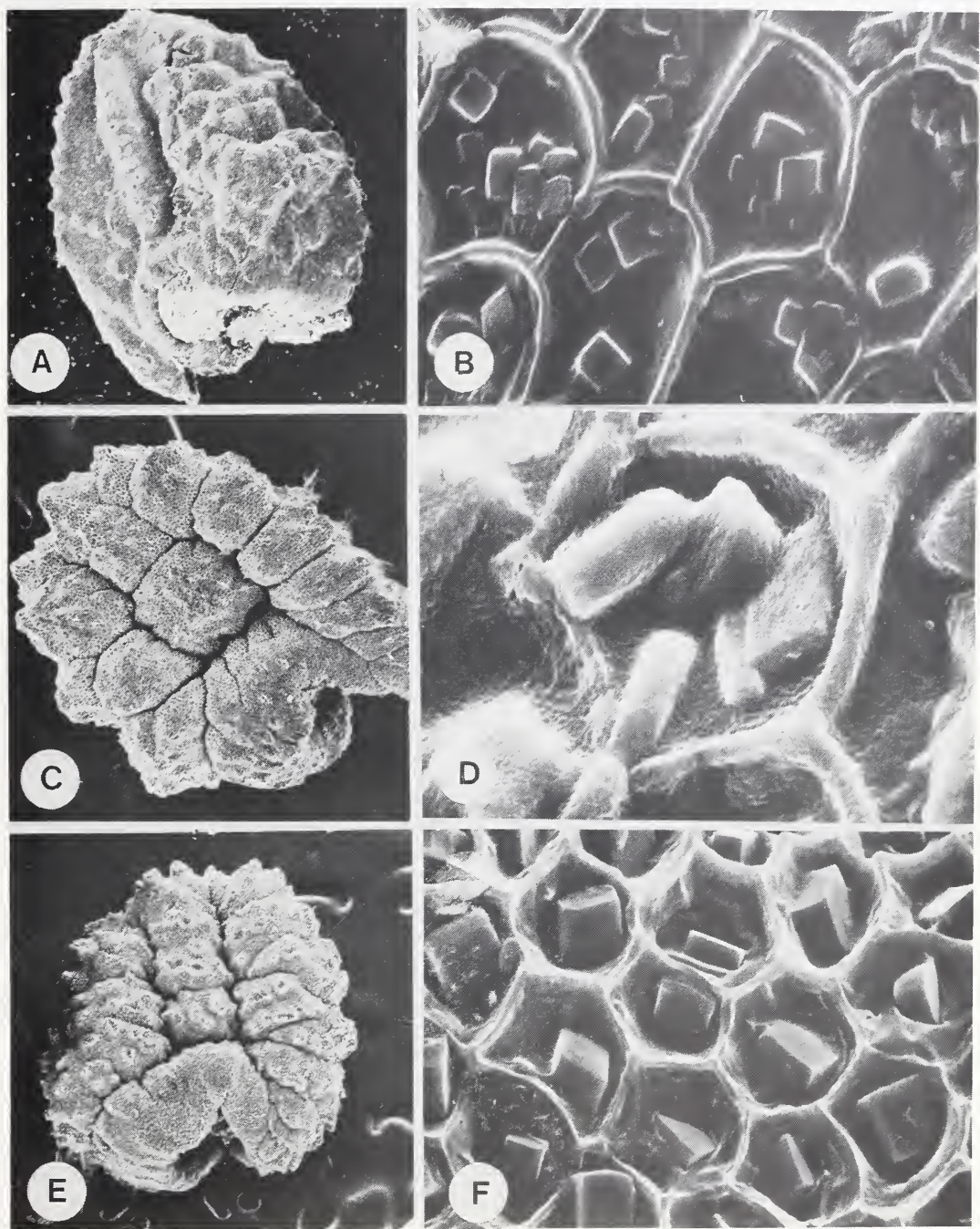


FIGURE 5.—*Justicia* sect. *Tyloglossa*: A–F. A,B,D, *J. petiolaris*: A, subsp. *petiolaris*, whole seed, $\times 30$; B, subsp. *incerta*, detail of seed, $\times 2700$; D, subsp. *petiolaris*, detail of seed, $\times 50$. C, F, *J. kirkiana*: C, whole seed, $\times 50$; F, detail of seed, $\times 2000$. E, *J. flava*, whole seed, $\times 50$.

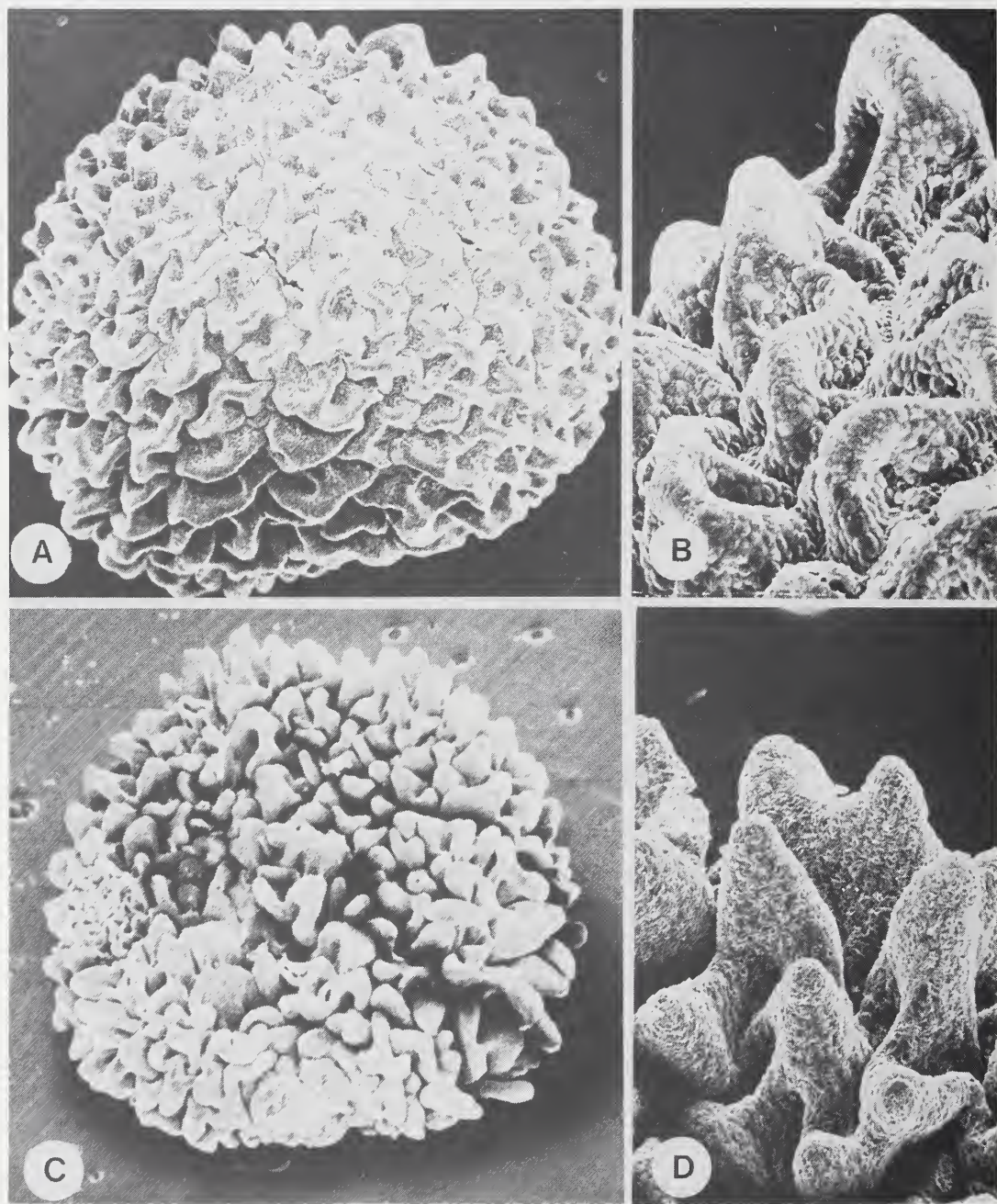


FIGURE 6. — *Justicia* sect. *Betonica*: A–D. A, B, *J. betonica*: A, whole seed, $\times 32$; B, detail of seed, $\times 70$. C, D, *J. montis-salinarum*: C, whole seed, $\times 50$; D, detail of seed, $\times 220$.

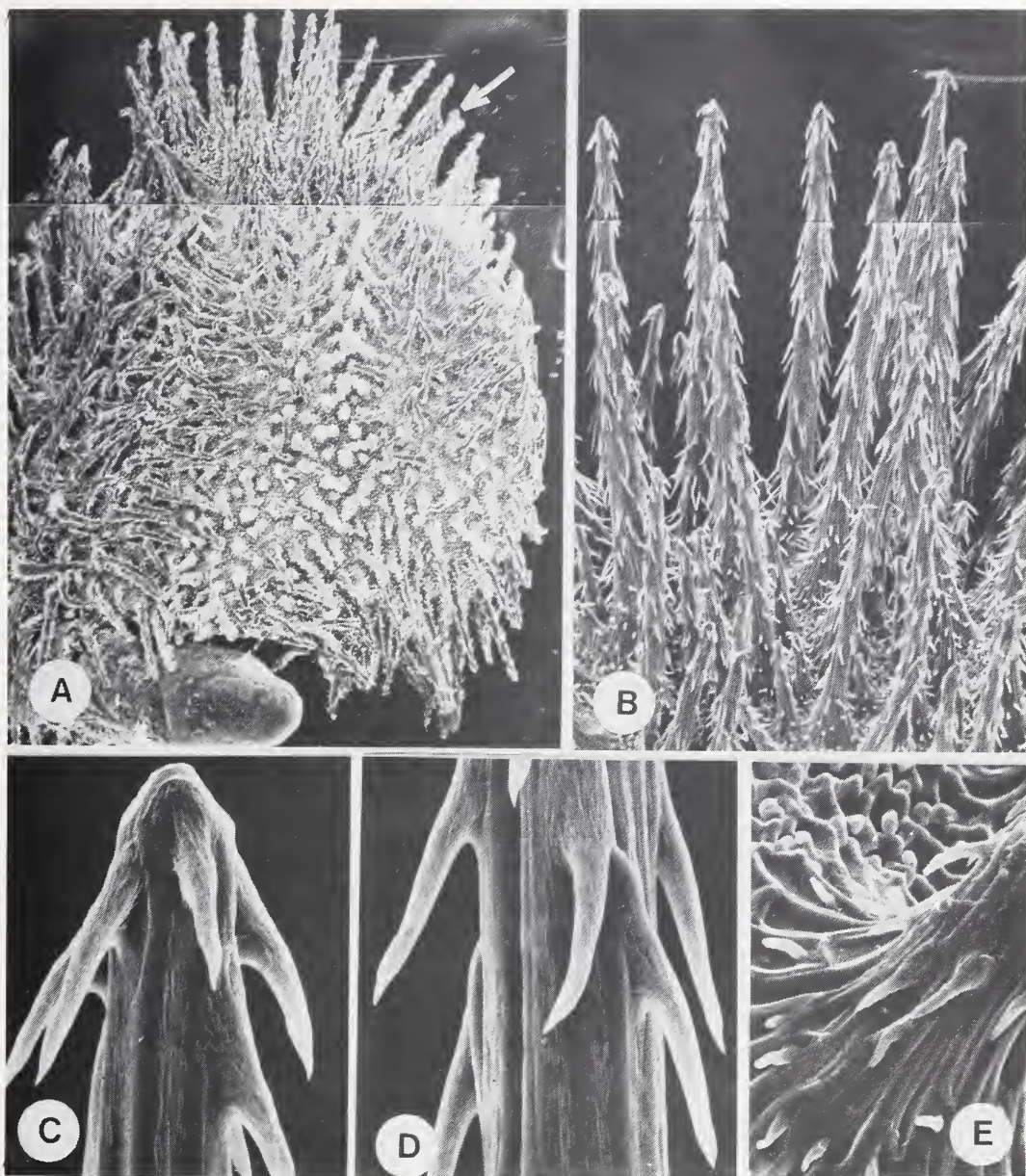


FIGURE 7.—*Justicia* sect. *Raphidospora*: A–E, *J. glabra*: A, whole seed (composite picture), $\times 55$; B, scales on seed (composite picture), $\times 190$; C, apex of scale, $\times 1800$; D, shaft of scale, $\times 1800$; E, base of scale, $\times 725$.

One other species was examined, which on flower and pollen characters possibly belongs in sect. *Harnieria*. This was *J. capensis* Thunb. (Figure 1A–C), which was placed in this section by Graham (1989). The seeds, however, are different from the papillate seeds of the other species in the section, being colliculate with a strongly reticulate micro-pattern.

CONCLUSION

Both macro- and micro-pattern of the seed testa may be considered of major importance in placing many species in their sections, and delimiting some sections in *Justicia*, but need to be used with caution as they do not always

correlate with other features. They are also suggestive of a relationship between some species of *Justicia* sect. *Harnieria* and *Siphonoglossa*.

ACKNOWLEDGEMENTS

This work was done as part of a Ph.D. thesis in the Department of Botany, University of Natal, Pietermaritzburg. I would like to thank Mrs S. Perold of the National Botanical Institute, Pretoria, for her assistance with the Scanning Electron Microscope and my supervisor, Dr F. Getliffe Norris, for her help and advice in the writing up of my thesis.

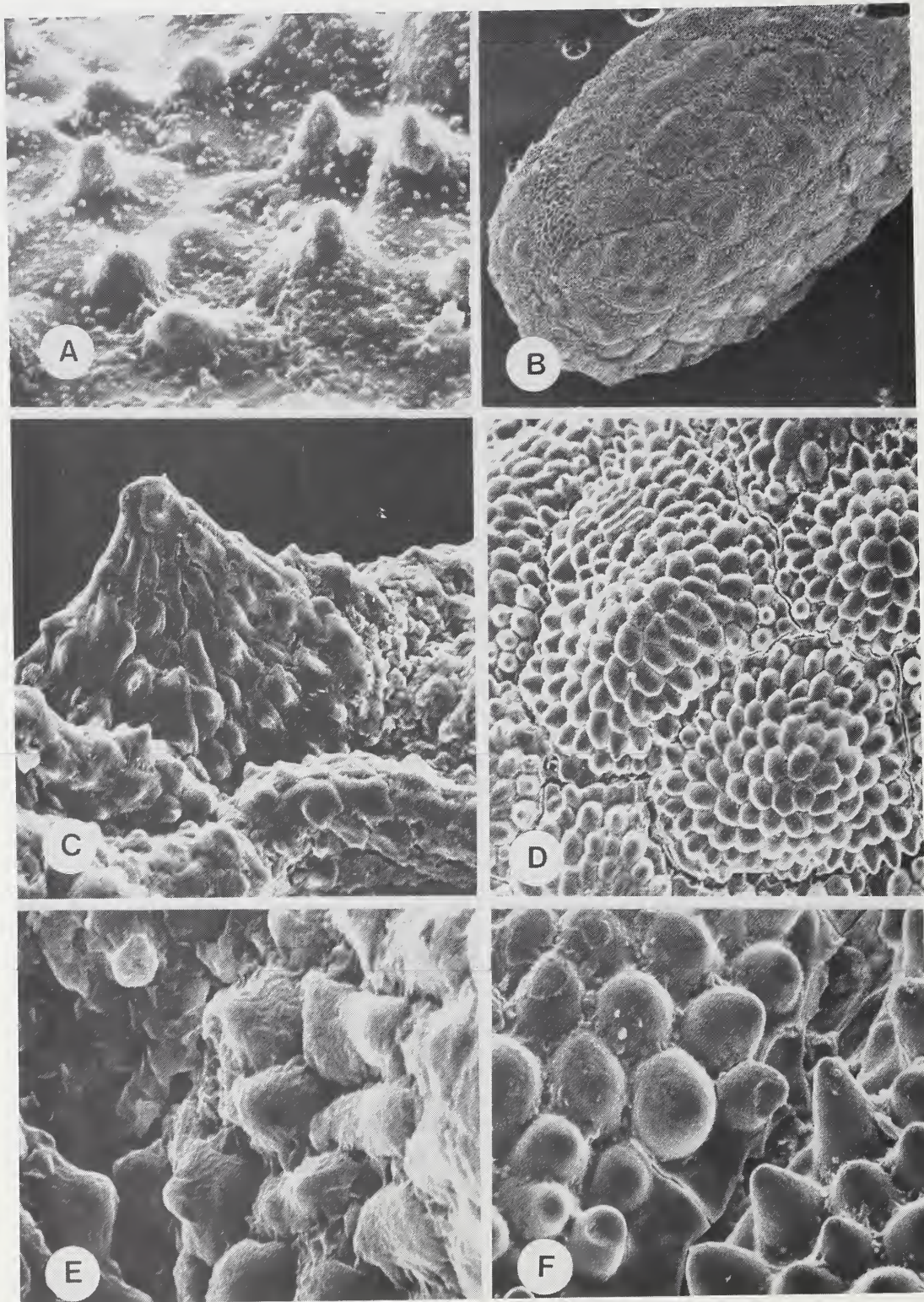


FIGURE 8.—*Siphonoglossa leptantha* subsp. *leptantha*: A, detail of seed (critical-point dried), $\times 2000$. *Justicia* sect. *Harnieria* p.p.: B–F, *J. dinieri*: B, whole seed from one-seeded capsule, $\times 60$; C–F, detail of seed, C, from four-seeded capsule, $\times 900$; D, from one-seeded capsule, $\times 370$; E, from four-seeded capsule, $\times 3000$; F, from one-seeded capsule, $\times 1000$.

REFERENCES

- BADEN, C. 1981a. The genus *Macrorungia* (Acanthaceae), a taxonomic revision. *Nordic Journal of Botany* 1: 143–153.
- BADEN, C. 1981b. The genus *Anisotes* (Acanthaceae). *Nordic Journal of Botany* 1: 623–664.
- BALKWILL, K. & GETLIFFE NORRIS, F. 1984. Taxonomic studies in the Acanthaceae: the genus *Hypoestes* in southern Africa. *South African Journal of Botany* 51: 133–144.
- BALKWILL, K. & GETLIFFE NORRIS, F. 1988. Classification of the Acanthaceae: a southern African perspective. *Monographs in Systematic Botany* 25: 503–516.
- BALKWILL, K., GETLIFFE NORRIS, F. & SCHOONRAAD, E. 1986. Taxonomic studies in the Acanthaceae: testa microsculpturing in southern African species of *Peristrophe*. *South African Journal of Botany* 52: 513–520.
- GIBSON, D.N. 1972. Studies in American plants III. *Fieldiana (Botany)* 34,6: 57–87.
- GRAHAM, V.A.W. 1989. Delimitation and infra-generic classification of *Justicia* (Acanthaceae). *Kew Bulletin* 43: 551–620.
- HANSEN, B. 1985. Taxonomic revision of the SE Asian species of *Isoglossa* (Acanthaceae). *Nordic Journal of Botany* 5: 1–13.
- HEDRÉN, M. 1987. The *Justicia capensis* species group (sect. *Harnieria*, Acanthaceae) in tropical Africa. *Kew Bulletin* 43: 349–359.
- HEDRÉN, M. 1988. The taxonomy of the *Justicia mollugo* group (*Justicia* sect. *Harnieria*, Acanthaceae). *Bulletin du Jardin botanique national de Belgique* 58: 129–158.
- IMMELMAN, K.L. 1987. *A study of the genera Justicia L. and Siphonoglossa Oerst. (Acanthaceae) in southern Africa*. Ph.D. thesis, University of Natal, Pietermaritzburg.
- IMMELMAN, K.L. 1989. Studies in the southern African species of *Justicia* and *Siphonoglossa* (Acanthaceae): palynology. *Bothalia* 19: 151–156.
- MANNING, J.C. & GETLIFFE NORRIS, F. 1985. Taxonomic studies in the Acanthaceae: a reappraisal of the genera *Duvernoia* and *Adhatoda* in southern Africa. *South African Journal of Botany* 51: 475–484.
- MUNDAY, J. 1980. *The genus Monechma Hochst. (Acanthaceae tribe Justiciae) in southern Africa*. M.Sc. thesis, University of the Witwatersrand, Johannesburg.

Studies in the southern African species of *Justicia* and *Siphonoglossa* (Acanthaceae): indumentum

K.L. IMMELMAN*

Keywords: Acanthaceae, *Justicia*, *Siphonoglossa*, trichomes, indumentum, southern Africa, taxonomy

ABSTRACT

The trichome types present on all species of *Justicia* and *Siphonoglossa* in the southern African region (as defined by the *Flora of southern Africa*) were examined with the dissecting and with the Scanning Electron Microscope. Both glandular and eglandular trichomes were observed, the former comprising both sessile, peltate glands and stalked glands of various lengths. Eglandular trichomes are either straight or sharply bent (anvil-shaped), and comprise two to many cells. They are either smooth or have raised ornamentation on the cell walls. The presence and morphology of the trichomes on various organs is recorded and measured, and the range of trichomes seen was illustrated. The possible significance of trichome type and ornamentation in the taxonomy and ecology of the genera is discussed.

UITTREKSEL

Die trigoomtipes aanwesig op al die *Justicia*- en *Siphonoglossa*-spesies in die Suider-Afrikastreek (soos deur die *Flora of southern Africa* omskryf) is met die disseksiemikroskoop en die aftaselektronmikroskoop ondersoek. Geklierde sowel as klierlose trigome is waargeneem: eersgenoemdes behels beide sittende, skildvormige kliere en gesteelde kliere van verskeie lengtes. Klierlose trigome is óf reguit óf skerp gebuig (aambeeldvormig) en bestaan uit twee tot baie selle. Hulle is óf glad óf het verhewe ornamentasie op die selwande. Die aanwesigheid en morfologie van die trigome by verskeie organe is aangeteken en gemeet, en die verskeidenheid trigome wat waargeneem is, is geïllustreer. Die moontlike belang van trigoomtipe en ornamentasie in die taksonomie en ekologie van die genusse word bespreek.

INTRODUCTION

The indumentum of all species of *Justicia* and *Siphonoglossa* found in southern Africa (as defined by the *Flora of southern Africa*) was examined. Numerous authors, including Ahmad (1974a, b; 1978), Munday (1980), Baden (1981), Balkwill & Getliffe Norris (1985), Hansen (1985) and Manning & Getliffe Norris (1985), have found pubescence and trichome types important as indicators of relationships in various genera of the Jussieaceae.

METHODS

Several specimens of each taxon were examined with the dissecting microscope and the eglandular and stalked glandular trichomes were measured using a micrometer eyepiece.

Indumentum type present was recorded from the stem, the leaf lamina and petiole/leaf base area, from the bracts, the inner and outer surface of the calyx and from the capsule. Material of one specimen of each species or subspecies recognized by Immelman (1987), except *J. crassiradix*, was examined under the SEM. The leaf, outer and inner surface of calyx as well as the bract and the leaf base/petiole area were scanned. Approximately 2×3 mm of leaf tissue (and also of the bracts where these were large) was removed from herbarium sheets. This was mounted directly onto 15 mm diameter aluminium stubs and glow-discharge-coated with $\pm 400 \text{ \AA}$ of metallic gold in an Eiko sputter coater. They were then viewed directly in an MSM 4 Hitachi-Akashi (desk top model) SEM at kv 15,

and photographed using a Mamiya 6×7 camera and Ilford FP 4 125 ASA film. The film was developed in Microdol X.

Where fresh material was available this was critical-point dried before being examined under the SEM. This was found to be preferable to using dried material as the trichomes, especially glandular trichomes, are then not collapsed and their structure can be more accurately observed. The material was dehydrated in 2,2-dimethoxypropane (DMP), fixed in FAA, and critical-point dried in a Balzer's Union critical-point drier using liquid carbon dioxide. It was then mounted, viewed and photographed as described above. Trichome types were defined and named according to the terminology used by Munday (1980). Presence or absence of the different types was recorded for the different organs mentioned above (Table 1). Figures were prepared illustrating the range of trichome types seen (Figures 1 & 2).

MORPHOLOGY

Two basic types of trichomes were found: 1, eglandular and 2, glandular.

1. *Eglandular trichomes* (Figure 1 and type 'A' on Table 1) are either straight (varying from long to short) or gradually to sharply bent. They consist of (1?)2 to many uniseriate cells with or without ornamentation.

In some species, e.g. *J. parvibracteata*, the trichomes are two-celled (Figure 1G). *J. montis-salarum* A. Meeuse appeared to have one-celled trichomes, but the trichomes were so heavily ornamented that it was not possible to see whether they were 1- or 2-celled (Figure 1H). In most other species one to many additional cells

* National Botanical Institute/Department of Agricultural Development, Private Bag X101, Pretoria 0001.
MS. received: 1989.06.23.

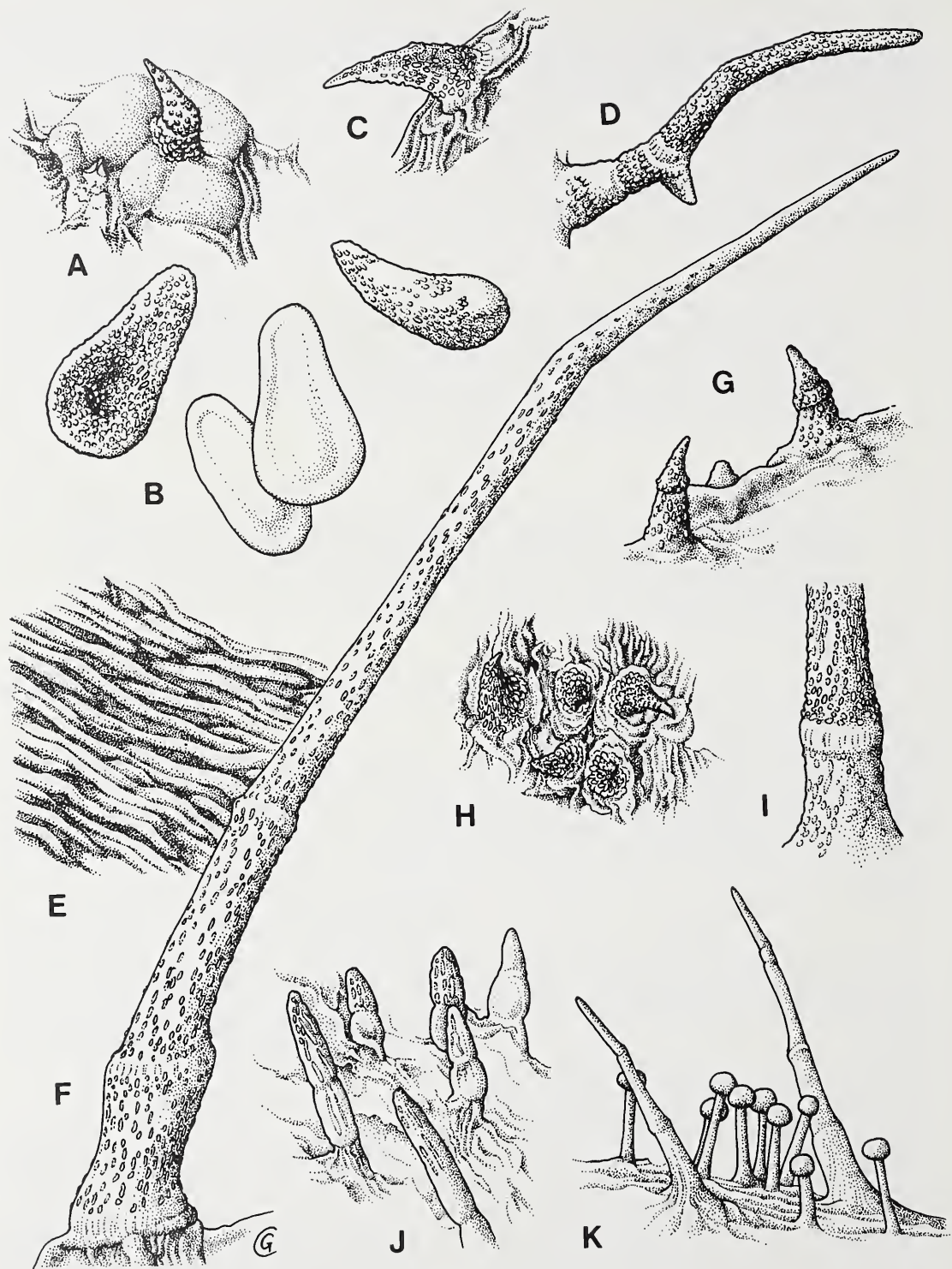


FIGURE 1.—Eglandular trichomes, all $\times 420$, except where otherwise stated. A, C, *J. protracta* subsp. *rhodesiana*, Germishuizen 974: A, from leaf showing swollen basal cells; C, from calyx. B, *J. cuneata* subsp. *hoerleiniana*, from leaf, with ornamented and non-ornamented heads, Dinter 6401; D, *J. capensis*, from leaf showing small branch on trichome, Immelman 375; E, *J. odora*, from leaf showing ornamented trichome surface, $\times 3000$, Meeuse 9530; F, *J. kirkiana*, from petiole, $\times 300$, Brummitt & Banda 8539; G, *J. parvibracteata*, from leaf, Esterhuizen 1101; H, *J. montis-salinarum*, from leaf, Van Wyk 5536. I, K, *J. protracta* subsp. *protracta*, Balkwill s.n.: I, from bract showing striate joint at cell wall; K, from leaf near petiole, showing eglandular and glandular trichomes in two separate layers, $\times 120$. J, *J. orchoides* subsp. *glabrata*, from bract, Muir 1101.

TABLE 1.—Trichome types present in taxa of *Justicia* and *Siphonoglossa*: A, eglandular trichomes; B, peltate glandular trichomes; C, stalked glandular trichomes

	Stem	Lf base	Lf lam.	Bract	Calyx (outer surface)	Calyx (inner surface)	Capsule
<i>Justicia</i>							
<i>anagalloides</i>	A	A	A B	A B	A B	A B	A
<i>anselliana</i>	A	A	A	A	A	A B	A
<i>betonica</i>	A	A	A B	A B	A B C	(?A)	A B
<i>bolusii</i>	A	A	A	A C	A C	—	A
<i>campylostemon</i>	A	A B C	A B	A B	—	C	—
<i>capensis</i>	A	A B C	A B	A B C	A B C	A C	—
<i>cuneata</i>							
subsp. <i>cuneata</i>	A	A	A	A	A	A C	—
subsp. <i>glabrata</i>	A	—	A	A	A	A C	—
subsp. <i>hoerleiniana</i>	A	A	A	A	A C	?	—
<i>dinteri</i>	A C	A C	A	A C	A C	A C	A
<i>flava</i>	A	A B	A B	A B C	A B C	?	A
<i>glabra</i>	A C	A B C	A B	A	A C	A C	—
<i>guerkeana</i>	A	A B	A B	A B	A B	A B	—
<i>kirkiana</i>	A C	A B	A B C	A B C	B C	A B C	A C
<i>minima</i>	A	A B	A B	A B	A B	A B	—
<i>montis-salinarum</i>	A	A B	A B	A ?B	A ?B	A ?B	A
<i>odora</i>	A	A B	A B	A B	A	A B	—
<i>orchioides</i>							
subsp. <i>latifolia</i>	—	—	—	A	A	A	—
subsp. <i>orchioides</i>	A	A	A	A	A	A	—
<i>parvibracteata</i>	A	A	A	A	A	A C	A
<i>petiolaris</i>							
subsp. <i>bowiei</i>	A	A B	A B	A B	A B	A B C	—
subsp. <i>incerta</i>	A	A B	A B	A B	A B	A B C	—
subsp. <i>petiolaris</i>	A	A B	A B	A B C	A B C	A B C	—
<i>platysepala</i>	A	A	A	A	A	A B	—
<i>protracta</i>							
subsp. <i>protracta</i>	A C	A B C	A B C	A C	A B	A C	A
subsp. <i>rhodesiana</i>	A	A C	A C	A C	A	A C	A
<i>thymifolia</i>	A	A	A	A	A	A ?B	—
<i>Siphonoglossa</i>							
<i>leptantha</i>							
subsp. <i>late-ovata</i>	A	A C	A C	A C	A	?	A
subsp. <i>leptantha</i>	A C	A C	A C	A C	A	?	A
<i>linifolia</i>	A C	A C	A C	A C	A	?	—
<i>nkandlaensis</i>	A	A	A	A C	A	?	—

are present, these being progressively narrower than the basal cell. The upper cells are frequently set at an angle to the one below, so that the trichome is gradually or sharply bent or even appressed to the surface of the organ on which they occur. The sharply bent condition (Figure 1A) has been described as anvil-shaped by Munday (1980). The basal cell of the eglandular trichomes is thicker and set into the epidermis. It is sometimes surrounded by a ring of swollen epidermal cells (e.g. *J. protracta* (Nees) T. Anders. —Figure 1A). In anvil-shaped trichomes, it is usually the second cell which is set at an angle to the basal cell. The terminal cell is usually pointed but in *J. cuneata* subsp. *hoerleiniana* (P. G. Mey.) Immelman it is swollen, with one end rounded and the other more pointed (Figure 1B). The terminal cell of *J. cuneata* subsp. *hoerleiniana* is either smooth or ornamented. Rarely, a branched trichome was encountered, as in *J. capensis* Thunb. (Figure 1D). The cells of the upper tiers are usually ornamented, except in those trichomes found on the inner surface of the calyx lobes. The ornamentation is striate to papillose (Figure 1E, cf. Figure 1F) but, as these types intergrade, no attempt was made to draw a distinction between them. The area of the joint between two cells is smooth and not ornamented except for a ring of vertical striations (Figure 1I).

In a number of taxa the eglandular and glandular trichomes form discrete layers with the eglandular being the longer, e.g. in *J. protracta* subsp. *protracta* (Figure 1K).

2. Glandular trichomes: two main types were recorded, peltate and stalked glands.

2.1 Peltate glands (Figure 2A–C; type ‘B’ in Table 1)

These glands consist of a solitary basal cell set as a wedge into the epidermis (Figure 2B). The head, set on the basal cell, is broad and flattened, and is probably four-celled. No sections were cut to confirm this, but the head is marked with two lines at right angles (probably cell walls, Figure 2A). The top of the head is sometimes marked with a faint ring where the lines cross. In *J. anagalloides* (Nees) T. Anders. (Figure 2C), each cell of the head has a single papilla on the outer edge. This feature is unique among the species of *Justicia* seen in this study.

2.2 Stalked glands (Figure 2D–G; type ‘C’ in Table 1)

The basal cell of stalked glands is similar to that of the peltate glands.

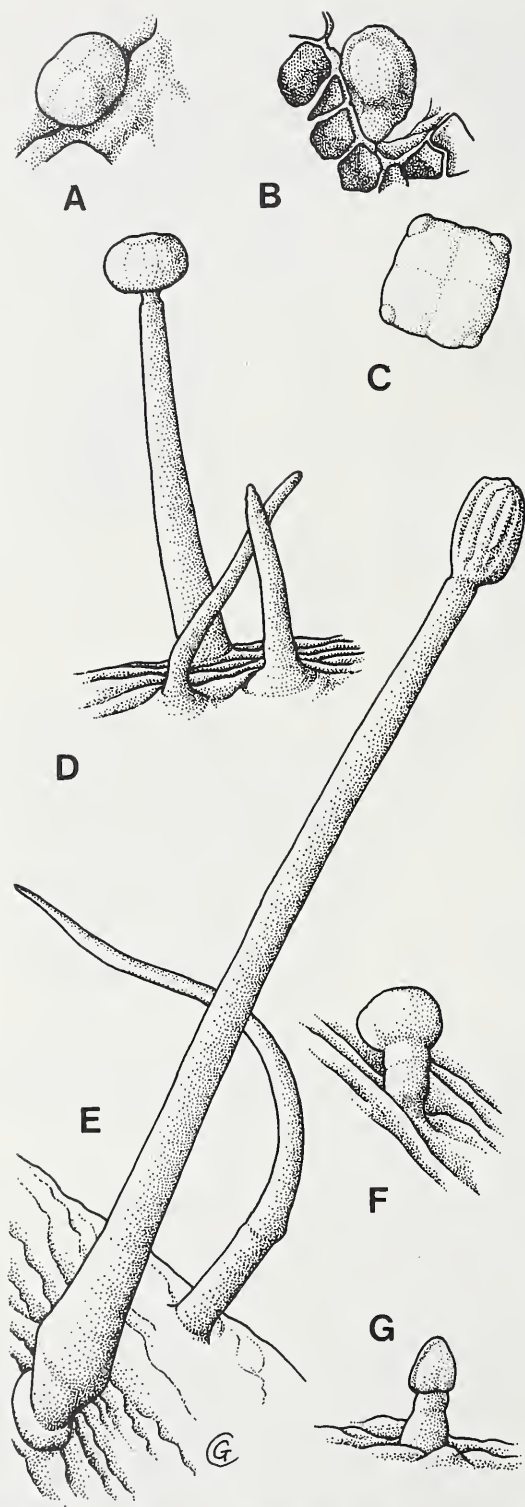


FIGURE 2. — Glandular trichomes, all $\times 600$, except where otherwise stated. A, B, D, *J. flava*, Immelman 249: A, leaf, peltate gland; B, leaf base, peltate gland showing wedge-shaped basal cell; D, bract, stalked gland with long stalk, $\times 240$. C, *J. anagalloides*, leaf base, peltate gland showing small protuberances at outer margin of each cell; E, *J. petiolaris*, calyx, stalked gland with long stalk; F, *J. protracta* subsp. *protracta*, inner surface of calyx, stalked gland with short stalk, Balkwill s.n.; G, *J. betonica*, calyx, stalked gland with short stalk, Immelman 178.

The stalk varies in length (0.02 mm in *J. protracta* subsp. *rhodesiana* (S. Moore) Immelman to 1.56 mm in *J. petiolaris* (Nees) T. Anders. subsp. *petiolaris*) and in the number of cells, and is not ornamented. Long-stalked glands on certain organs are characteristic of some species, e.g. the bracts of *J. kirkiana*, *J. petiolaris* subsp. *petiolaris* (Figure 2E), and sometimes of *J. flava* (Vahl) Vahl, have very long glandular trichomes.

Below the head is a collar cell, which is shortly cylindrical and usually narrower than the rest of the stalk (Figure 2D).

The glandular heads are of various types, and are occasionally species-specific. In *J. betonica* L., for instance, the glands on the petiole (when present) have elongated clavate heads, while those on the calyx have the heads broad at the base and narrowing towards the apex (Figure 2G). In some species the head is longitudinally faintly striate (?cell walls). It is either the same width as the stalk and longer than wide (Figure 2E) or much wider than the stalk and wider than long (pin-shaped glands) (Figure 2D, F, G).

The number of cells in the head is uncertain, as no sections were cut, but accounts in the literature (Ahmad 1978) record from 1 to 17 cells in trichomes of the family.

TAXONOMIC VALUE

On the basis of indumentum morphology, *Siphonoglossa* could not be distinguished from *Justicia*. It was also not possible to delimit sections within these genera, or in the related genus *Monechma*, solely on indumentum features. Some of the trichome types Munday (1980) found in *Monechma* are very rare or absent altogether from the species of *Justicia* seen in this study. These types are glandular papillae with the tip not wider than the stalk, T-shaped eglandular trichomes, flattened uniseriate eglandular trichomes, and dendroid trichomes. Anvil-shaped trichomes having broad flattened shoe-like heads were rare in *Justicia* but relatively common in *Monechma*. However, as none of these trichomes were exclusive to either of the genera, they cannot be used to distinguish them at generic level.

At species and subspecies level, however, the trichomes in *Justicia* provide many useful characters, and are sometimes characteristic of one or a few species. The following species, for example, have very long-stalked glands on the bracts: *J. kirkiana*, *J. flava* (Figure 2D), *J. dinteri* and *J. petiolaris* subsp. *petiolaris* (Figure 2E). In the case of *J. kirkiana* and *J. dinteri*, these glands give the bracts a cottony appearance. Some species, such as *J. parvibracteata* and *J. montis-salinarum*, are puberulous, with a dense indumentum of short, heavily ornamented trichomes. One species pair among the southern African species of *Justicia* is most easily distinguished on pubescence characters. Because differences also exist in other characters it seems reasonable to maintain these taxa at specific rank. They are *J. platysepalae*, which has leaves with sparse to dense pubescence, whereas in the closely related *J. guerkeana* the leaves are usually completely glabrous. In *J. guerkeana* the leaves are also three-veined from the base and there is a difference in distribution.

The pubescence is the most reliable morphological feature for distinguishing certain subspecies. Because there was also a degree of geographical separation, they were recognized at subspecific rank. *J. cuneata*, for example, has the following three subspecies: subsp. *latifolia* is glabrous except on the stems and on the inside of the calyx lobes, subsp. *cuneata* is densely puberulous on all vegetative parts as well as the exterior of the calyx, and subsp. *hoerleiniana* has a dense covering of broad-headed anvil-shaped trichomes. Another example, *J. protracta* subsp. *protracta*, has multicellular eglandular trichomes averaging 0,47 mm in length (on the leaf lamina), whereas in subsp. *rhodesiana* the whole plant is densely puberulous with short, two-celled eglandular trichomes, of which the average length (on the leaf lamina) is 0,04 mm. *J. orchoides* subsp. *orchoides* has stiff opaque white trichomes on stem and leaves while subsp. *glabrata* is glabrous.

In *Justicia*, four taxa from arid areas have dense to moderately dense long pubescence: *J. dinteri*, *J. anseliana*, *J. guerkeana* and *J. cuneata* subsp. *hoerleiniana*. The last taxon, a woody shrub, has an indumentum type unique in the genus, though present in the related *Monechma*. The very dense eglandular trichomes have large swollen shoe-shaped heads which sit at 45–90° to the stalks.

In some taxa, the indumentum is reduced or even lacking (except for the sessile glands, see Table 1). Examples are *J. orchoides* subsp. *glabrata*, *J. crassiradix* and *J. odora*.

ECOLOGICAL SIGNIFICANCE

A number of probably closely related pairs of *Justicia* species or subspecies are known of which one member occurs in a more arid environment, and possesses an indumentum markedly different from that of the other. These are *J. montis-salinarum* and *J. betonica*, *J. protracta* and *J. dinteri*, *J. protracta* and *J. parvibracteata*, *J. protracta* subsp. *protracta* and *rhodesiana* and *J. cuneata* subsp. *cuneata* and *hoerleiniana*. The last taxon occurs in the most arid environment of any of the southern African taxa of *Justicia*, in the Sperrgebiet of southern Namibia.

Johnson (1975), after reviewing the evidence for the presence and density of pubescence in geographical areas of different moisture stress, concludes that 'It thus seems clear that ecogeographic relationships of pubescence must involve factors in addition of moisture'. It is even possible, he suggests, that the presence of trichomes increases the rate of transpiration, and that their function may rather be to act as a light shield in areas with intense radiation. Uphof & Hummel (1962) make a similar suggestion, though they stress that experimental proof is lacking. The bent shape and heavier ornamentation of trichomes of some species would seem to add to the effectiveness of such trichomes as light shields. They state: '... the faculty to function as a screen against the light would depend on the presence of a large number of light-dispersing centres. The latter may be present in the form of knobs on the cell-wall or on the cuticle only or in that of more or less sharp bends in the trichomes.'

This provides a possible explanation for the predominance of short dense pubescence, consisting of bent trichomes having heavy ornamentation, in many of those species of *Justicia* occurring in arid or semi-arid areas.

Species with such a dense puberulous indumentum in which the trichomes are shorter and more heavily ornamented than is generally found in species from moister areas include *J. cuneata* subsp. *cuneata* (W Karoo), *J. protracta* subsp. *rhodesiana* (Namibia, Botswana, N Transvaal, Zimbabwe), *J. parvibracteata* (N Cape) and *J. montis-salinarum* (Soutpansberg of the Transvaal). When examined under a dissecting microscope these species all appear minutely puberulous. When the trichomes are examined under the SEM, they are seen to be reduced to (1)2 cells. If the trichome is 2-celled, then the upper cell is at an angle to the basal cell. The whole surface is heavily ornamented with papillae, which are noticeably denser and more projecting than in other species of the genus.

Monechma, a genus predominantly of dry areas, was found by Munday (1980) to have many species with puberulous leaves, especially those occurring in the southern part of Namibia. There are, however, exceptions to this tendency, as in *Justicia*, where *J. orchoides* subsp. *glabrata* from the Karoo is glabrous.

Taxa with reduced or even lacking indumentum (except for the sessile glands) (see Table 1) are found in both arid regions (e.g. *J. orchoides* subsp. *glabrata* from the Karoo), and in moist, even marshy, habitats, e.g. *J. crassiradix*, *J. odora* and sometimes *J. capensis*.

It is considered probable that the function of the trichomes in reflecting light is more significant than in water conservation, and their shape and ornamentation may be important in this regard. However, no clear-cut picture has emerged, where a single type of indumentum (or even its absence) could be consistently correlated with aridity or geographical distribution.

CONCLUSIONS

Two basic types of trichomes were found: eglandular and glandular. In most species both types are present. It was not possible to distinguish genera or sections on the basis of indumentum morphology. At species and subspecies level, however, trichomes provide many taxonomically useful characters. No clear-cut correlation was found between indumentum and habitat, but a predominance of short, dense pubescence was noted in many *Justicia* species from arid and semi-arid areas.

ACKNOWLEDGEMENTS

This work was based on a Ph.D. thesis done in the Department of Botany, University of Natal, Pietermaritzburg. I would like to thank Mrs S. Perold of the National Botanical Institute, Pretoria, for her assistance with the Scanning Electron Microscope, Ms Gill Condy for her illustrations, and my supervisor, Dr F. Getliffe Norris, for her help and advice in the writing up of my thesis.

REFERENCES

- AHMAD, A.D.Q. 1974a. Cuticular studies in some Nelsonioideae (Acanthaceae). *Botanical Journal of the Linnean Society* 68: 73-80.
- AHMAD, A.D.Q. 1974b. Cuticular studies in some species of *Mendoncia* and *Thunbergia* (Acanthaceae). *Botanical Journal of the Linnean Society* 69: 53-63.
- AHMAD, A.D.Q. 1978. Epidermal trichomes of Acanthaceae. *Blumea* 24: 101-117.
- BADEN, C. 1981. The genus *Macrorungia* (Acanthaceae), a taxonomic revision. *Nordic Journal of Botany* 1: 143-153.
- BALKWILL, K. & GETLIFFE NORRIS, F. 1985. Taxonomic studies in the Acanthaceae: the genus *Hypoestes* in southern Africa. *South African Journal of Botany* 51: 133-144.
- HANSEN, B. 1985. Taxonomic revision of the SE Asian species of *Isoglossa* (Acanthaceae). *Nordic Journal of Botany* 5,1: 1-13.
- JOHNSON, H.B. 1975. Plant pubescence: an ecological perspective. *Botanical Review* 41: 233-258.
- MANNING, J.C. & GETLIFFE NORRIS, F. 1985. Taxonomic studies in the Acanthaceae: a reappraisal of the genera *Duvernoia* and *Adhatoda* in southern Africa. *South African Journal of Botany* 51: 475-484.
- MUNDAY, J. 1980. The genus *Monechma* Hochst. (Acanthaceae tribe *Justiciae*) in southern Africa. M.Sc. thesis, University of the Witwatersrand, Johannesburg.
- UPHOF, J.C.Th. & HUMMEL, K.K. 1962. Plant trichomes. In *Encyclopaedia of plant anatomy* 10,1: 1-206. Nicolasse, Berlin.

Notes on African plants

VARIOUS AUTHORS

ASTERACEAE

A NEW SPECIES OF *PTEROTHRIX* (GNAPHALIEAE) FROM THE NORTHERN CAPE

Pterothrix tecta Brusse, sp. nov.

Frutex clonalis usque ad 400 mm altus et 3,5 m latus, aromaticus. *Caules principales* tortiles, atrocineri, usque ad 40 mm diametro, infra in arena infossi. *Rami secundarii* usque ad 5 mm crassi, cortice tenui, aureo-badio vel badio vel passim rubescenti, longistrorsum fissurato, glabri vel aureo-pelliculato. *Rami tertiarii* robusti, primum lutei et albo-tomentosi dein aurei, glabri et pelliculati. *Folia* alterna, sessilia, linearia, 1–11 × 0,7–2,2 mm, ad basin latissima, primum ascendencia dein patentia, marginibus involutis. Pagina superior canaliculata, albo-lanuginosa. Pagina inferior glabrescens, praesertim ad basin folliculata; costa praecipue ad basin prominente. Apex obtusus, mucrone minimo, inconspicuo. *Capitula* solitaria, terminalia, sessilia, discoidea, cylindrica, 7–8 × 2,5–3,5 mm, 11–13-flora. *Bractee involucri* 8–10-seriatae, interiores exterioribus longiores, apicibus pellucidis, aeneis, cucullatis. *Bractee intimae* glabrae, lanceolatae, 6 × 0,8–1,0 mm. *Bractee aliae* ovatae, 1,5–6,0 × 1,5–2,0 mm, stereomis integris, ad apices versus cum areolis conspicue albo-tomentosis (ut in *Amphiglossa tomentosa* (Thunb.) Harv.). *Receptaculum* favosum, nudum. *Flores* omnes hermaphroditi, omnes fertiles, circa 7 mm longi. *Corolla* desuper alba vel lilacina, circa 5,5 mm longa, apicem versus quinquelobata; tubus cylindricus, 5 mm longus, vertice purpurascens, infime pallide virescens; lobi deltoidei, 0,5–0,7 mm longi, acuti, patentes. *Stamina* quinque; filamentum 1,30–2,55 × 0,08–0,17 mm; collum filamenti 0,26–0,47 mm longum, ad basin 0,08–0,11 mm latum, cellulis 9–11-seriatis; thecae 1,37–2,00 mm longae; appendix apicalis lanceolata, 0,27–0,43 × 0,11–0,17 mm, apice obtuso; caudae 0,40–0,68 mm longae, infra pubescentes (Figura 4); pollen spinulosum, 21–29 µm diametro, 3-colporatum. *Stylus* 3,5–4,5 × 0,12–0,20 mm, ad apicem versus biramosus, ramis 0,87–1,22 mm longis, truncatis. *Stylopodium* 0,19–0,37 mm latum. *Nectarium* 0,20–0,29 mm altum, 0,25–0,31 mm latum. *Ovarium* 1,0–1,8 mm longum, glabrum, cremeum, quinquecostatum; apex annulo incrassato. *Setae pappi* liberae, plumosae, sed ad basin hamatae, 3,5–4,5 mm longae.

TYPUS.—Cape Province, 2822 (Glen Lyon): Hay District, Witsand, some 70 km SW of Postnasburg. Farm Witsands 250. Approximately 2 km W of Doornaar homestead. White Kalahari Sand outlier, just W of the Langeberg. Clump-forming shrub, up to 400 mm tall, and up to 3,5 m wide. Florets white or pale mauve from above. Involucral bracts a golden colour. Main stems gnarled, dark grey, up to 40 mm diam., buried in sand below. Bark poorly developed. Leaves with camphor odour when crushed. Occurs in sparsely grassy dune shrubland, with *Lopholaena cneorifolia* and *Crotalaria virgultalis*, in

locally level place on E slope, near summit of rocky hill, overlain with white dune sand. Locally common. Alt. 1 230 m (-CB). *F. Brusse* 5629, 26.11.1989 (PRE, holo.; AD, B, BAF, BH, BM, BOL, BR, BRI, C, CAN, CANB, COI, E, EA, G, GH, GRA, HBG, J, K, L, LD, LG, LISU, LMA, M, MEL, MO, NBG, NH, NSW, NU, O, P, R, S, SRGH, U, UC, UPS, US, W, WAG, WIND, Z, iso.). Figure 1.

Clonal shrub up to 400 mm tall and 3,5 m across, aromatic. *Main stems* gnarled, dark grey, up to 40 mm diam., buried in sand below. *Secondary branches* up to 5 mm thick, bark thin, golden chestnut brown to reddish-brown to reddish in places, longitudinally fissured, glabrous or with golden flakes. *Tertiary branches* robust, yellow and white-tomentose when young, golden-yellow, glabrous and peeling when older. *Leaves* alternate, sessile, linear, 1–11 × 0,7–2,2 mm, broadest at base, ascending but spreading in upper half, margins involute. Upper surface canaliculate, white-woolly. Lower surface



FIGURE 1. — *Pterothrix tecta* Brusse, habit. *F. Brusse* 5629, holotype.



FIGURE 2. — *Pterothrix tecta* Brusse, flowering twigs at the type locality, with the tomentose patches on the involucral bracts clearly visible, F. Brusse 5629.

glabrous, epidermis sloughing-off and folliculate especially at base; midrib raised particularly at base. Apex obtuse, mucro very small, inconspicuous. *Flower heads* solitary, terminal, sessile, discoid, cylindrical, 7–8 × 2,5–3,5 mm, 11–13-flowered. *Involucral bracts* 8–10-seriate, becoming progressively longer inwards, tips galeate (hooded), pellucid, bronze. Innermost bracts glabrous, lanceolate, 6 × 0,8–1,0 mm. Remaining bracts ovate, 1,5–6,0 × 1,5–2,0 mm, stereomes entire, with conspicuous white-tomentose patches at apices (as in *Amphiglossa tomentosa* (Thunb.) Harv.). *Receptacle* honey-combed, nude. *Florets* all hermaphrodite and fertile, about 7 mm long. *Corolla* white or pale mauve from above, about 5,5 mm long, five-lobed towards apex; tube cylindrical, 5 mm long, purplish above becoming pale greenish below; lobes deltoid, 0,5–0,7 mm long, acute, spreading. *Stamens* five; filament 1,30–2,55 × 0,08–0,17 mm; filament collar 0,26–0,47 mm long, 0,08–0,11 mm wide at base, 7–11 cells across; thecae 1,37–2,00 mm long; apical appendage lanceolate, 0,27–0,43 × 0,11–0,17 mm, apex obtuse; tails 0,40–0,68 mm long, pubescent below, well exceeding filament collar base (Figure 4); pollen spinulose, 21–29 µm diam., 3-colporate. *Style* 3,5–4,5 × 0,12–0,20 mm, two-branched towards apex,



FIGURE 3. — *Pterothrix tecta* Brusse, close-up of some flower heads at the type locality, with the conspicuous white tomentose patches on the involucral bracts clearly visible, F. Brusse 5629.



FIGURE 4. — *Pterothrix tecta* Brusse, photomicrograph of the pubescent anther tails, extending well beyond the filament collar base, I.A.W. MacDonald 76/43, paratype. Bar = 0,3 mm.

branches 0,87–1,22 mm long, truncate. *Stylopodium* 0,19–0,37 mm wide. *Nectary* 0,20–0,29 × 0,25–0,31 mm, 5-buttressed like a *Diosma* fruit. *Ovary* 1,0–1,8 mm long, glabrous, cream, 5-ribbed, apex with thickened ring. *Pappus bristles* free, plumose, but base barbed; 3,5–4,5 mm long.

The present new species belongs to the genus *Pterothrix*, but this genus is closely related to the genus *Amphiglossa*, and a problem of generic assignment thus arose. However, the two genera can be distinguished by the following key:

- Heads homogamous, composed entirely of bisexual disc florets. Anther tails pubescent below, or tipped with well developed tail antlers *Pterothrix* DC.
- Heads heterogamous, composed of marginal, female ray florets and bisexual disc florets. Anther tails glabrous or simple, without well developed tail antlers *Amphiglossa* DC.

Pterothrix tecta resembles *Amphiglossa tomentosa* (Thunb.) Harv. in the almost identical complement of involucral bracts; all except the innermost row, possess

a very conspicuous median patch of white tomentum (Figures 2 & 3). However, *A. tomentosa* is a true *Amphiglossa*, with a few ray florets present in each head, and with glabrous anther tails, that extend for only a short distance beyond the base of the filament collar. *P. tecta*, on the other hand, lacks any female or ray florets, and the anther tails are pubescent below, with well developed tail antlers, that extend well beyond the filament collar base (Figure 4). *A. tomentosa* is a plant with wiry twigs, whereas *P. tecta* is one with comparatively robust twigs.

The authentic material of *Pterothrix flaccida* Schltr. nom. nud. (Hutchinson 1917) has the same conspicuous tomentose patches on the bracts, has heads that clearly contain a few ray florets each, and has anther tails that are glabrous. The material is therefore clearly assignable to *Amphiglossa tomentosa* (Thunb.) Harv., and the name *P. flaccida* Schltr. nom. nud., should not be validated.

Pterothrix tecta is distinct from all the other species in *Pterothrix*, by the broader involucre bracts, each with a

conspicuous white-tomentose patch. The other species all have lanceolate involucre bracts, which are glabrous or irregularly tomentose. *P. tecta* is also distinct from all other species of *Pterothrix* in possessing anther tails that extend well beyond the filament collar base (Figure 4), whereas those of all other species only just exceed the base of the filament collar, exemplified by the widespread and common *P. spinescens* DC. (Figure 5).

The following key serves to distinguish all the presently known narrow-leaved species of *Pterothrix*—*P. cymbifolia* Harv. is the only broad-leaved species known (Harvey 1865):

- 1a Anther tails well exceeding filament collar base. Except for the innermost row, involucre bracts about 2 mm broad, each with a conspicuous median white-tomentose patch (as in *Amphiglossa tomentosa*). Florets 11–13 per head *P. tecta* Brusse
- 1b Anther tails only just exceeding filament collar base. Involucre bracts lanceolate, all about 1 mm broad, glabrous or irregularly tomentose. Florets less than 10 per head:
 - 2a Stylopodium bulbous, clearly off-set from style. Leaves fascicled *P. perotrichoides* (DC.) Harv.
 - 2b Stylopodium not clearly off-set from style, running into style imperceptibly. Leaves alternate, not fascicled:
 - 3a Plant spiny. Capitula with 4–7 florets each .. *P. spinescens* DC.
 - 3b Plant not spiny. Capitula with 3 florets each .. *P. thuja* Merxm.

Like *P. spinescens*, *P. tecta* is aromatic, and gives off a camphor odour when the leaves are crushed.

Pterothrix tecta grows in clones up to 3,5 m across, but only grows up to 400 mm above the sand level (Figure 6). The clones may constitute single plants with most of the large stems buried in sand. The species was not found in pure sand areas but only in sand fills between sandstone outcrops. This may indicate that this plant may be rooted in rocky soil, with the main stems buried in the loose white sand, and the aerial shoots visible above the soil level as in Figure 6. However, no excavation was carried out to confirm this. The plant was not found in rocky places without sand, or where the sand fill was not substantial. The species occurred on the east side of Witsand, in level sand fills on east slopes near the summits of these rocky hills covered in white sand. These places were actually gently sloped in a westerly direction, not level (Figure 6).

Attempts to find this plant at other sand dune-covered rocky hills nearby, namely at Prynnsberg (north of Kheis

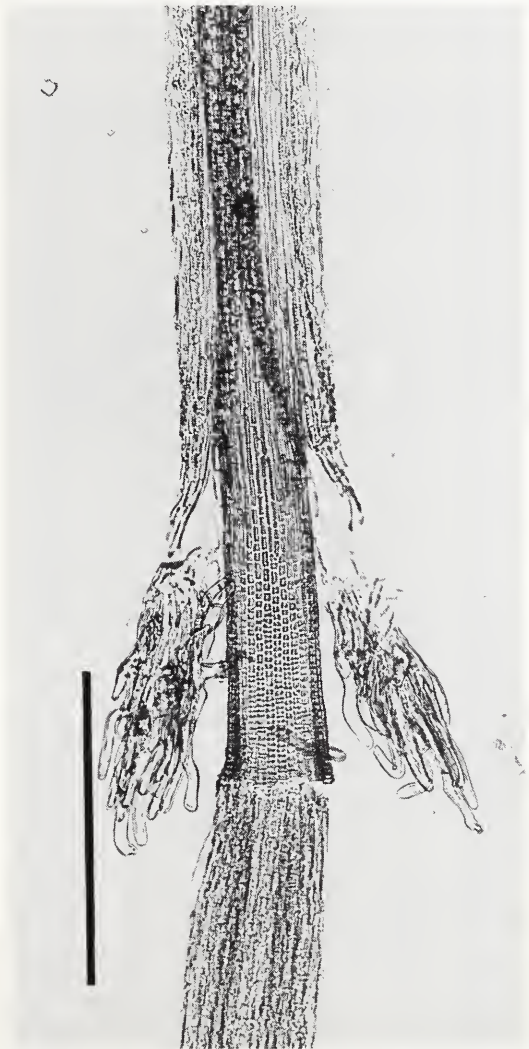


FIGURE 5.—*Pterothrix spinescens* DC., photomicrograph of the pubescent anther tails, only slightly exceeding the filament collar base, H.G. Flanagan 1454 (PRE). Bar = 0,3 mm.



FIGURE 6.—*Pterothrix tecta* Brusse, a clone of plants, looking eastward with the Langeberg in the distance, F. Brusse 5629.

on the Orange River) and Donkieberg, on the Farm Waterford (on the main Griquatown—Groblershoop road) proved fruitless. These latter dunes were composed of red sand, unlike that of Witsand. It therefore seems likely that this new species occurs only at Witsand, some 70 km south-west of Postmasburg.

CAPE PROVINCE.—2822 (Glen Lyon): Witsand, Hay. 28°32'S : 22°28'E. On white sand dunes. A common bush with dull yellow/brown flowers (—CB). *I.A.W. MacDonald* 76/43, 26.II.1976 (KMG, PRE).

REFERENCES

- HARVEY, W.H. 1865. Compositae. In W.H. Harvey & O.W. Sonder, *Flora capensis* 3: 275–276. Hodges & Smith, Dublin.
HUTCHINSON, J. 1917. Plants collected in the Percy Sladen Memorial Expeditions, 1908–1911. Compositae. *Annals of the South African Museum* 9: 379.

F. BRUSSE

MS. received: 1989.04.20.

FABACEAE

STUDIES IN THE GENUS *LOTONONIS* (CROTALARIEAE). 10. *L. ESTERHUYSENIANA*,
A NEW SPECIES FROM THE SOUTH-WESTERN CAPE

INTRODUCTION

The taxonomic position of an undescribed species with a superficial similarity to species of the section *Leorbordea* (Del.) Benth. is considered in this paper. At first, the morphology did not seem unusual, but on closer examination it became clear that the species did not fit readily into any of the existing sections of *Lotononis* (DC.) Eckl. & Zeyh. The significance of the new species described below is that it indicates a direct relationship between the *L. pentaphylla* group [presently part of the section *Lipozygis* (E. Mey.) Benth., see Van Wyk 1989] and the section *Leorbordea*. In terms of appearance however, it is rather insignificant.

A summary of similarities and differences between the new species and various groups of *Lotononis* is given in Table 1. The comparison shows that it has more in common with the sections *Leorbordea* and *Lipozygis* than with *Leptis* (Eckl. & Zeyh.) Benth. It differs from *Leorbordea* mainly in the alternate leaf arrangement and the smaller number of ovules and seeds. The character states also agree well with those of *Lipozygis* (*L. pentaphylla* group) except for the structure of the calyx and inflorescence. The only way to retain the present diagnostic value of the opposite leaf arrangement (for *Leorbordea*) and the capitate inflorescence (for the *L. pentaphylla* group) would be to exclude the new species from these two groups. The very small number of ovules and the unusual combination of other characters are of sufficient diagnostic value to form a new monotypic section. This seems the most practical solution.

Lotononis esterhuyseniana B-E. van Wyk, sp. nov., distincta sine affinitatibus manifestis. Similis est *L. platycarpae* (Viv.) Pichi-Serm. aliisque speciebus sectionis *Leorbordeae*, sed ab illis foliis alternis in ramis floriferis atque ovulis valde paucioribus (1 vel 2, non 5 vel ultra ut in *Leorbordea*) differt. Etiam similis est *L. laticipi* B-E. van Wyk aliisque speciebus gregis *L. pentaphyllae* (sectionis *Lipozygis*), ab illis inflorescentia racemosa (non capitata), lobo carinali calycis parvo, leguminibus maioribus compressis atque calyce non inflato non legumen maturum includente, differt. Etiam similis est *L. microphyllae* Harv. (sectionis *Leptidis*), sed ab illa habitu annuo, fabrica calycis, forma longitudineque vexillae et numero parvo ovulorum differt.

TYPE.—Cape Province, 3219 (Wuppertal): Ceres District, Stompiesvlei, Swartruggens (in sand near pan, 4000 ft.), 19.II.1961, *Esterhuysen 2934l* (BOL, holo.; C, K, MO, iso.). Figure 7.

The species is named after Miss Elsie Esterhuysen of the Bolus Herbarium, who collected and distributed the only material known so far. Through her numerous collections of rare and unusual species, Miss Esterhuysen has made a very significant contribution to the phyto-geography and taxonomy of *Lotononis*.

Prostrate annual up to 0.4 m wide. *Branches* sparsely leafy, minutely hirsute. *Leaves* invariably 3-foliolate, (5–)8–12(–15) mm long; petiole as long or longer than the terminal leaflet; leaflets relatively small, obovate, (2–)5–7(–9) × (1–)2–4(–5) mm, base cuneate, apex rounded to truncate, minutely but densely pubescent on both surfaces. *Stipules* single at each node, small, lanceolate to ovate, up to 3 × ± 1.5 mm, minutely pubescent on both surfaces. *Inflorescences* in terminal and leaf-opposed racemes, (3–)6–12(–15)-flowered; peduncle short, (2–)3–6(–12) mm long; bracts small and inconspicuous, lanceolate, ± 1 mm long; bracteoles absent. *Flowers* small, 7–8 mm long, yellow; pedicel up to 2 mm long. *Calyx* subequally lobed but with the lower lobe much narrower and slightly shorter than the upper four lobes; lateral sinuses a little shallower than the upper and lower ones; lobes narrowly triangular, acute. *Standard* suborbicular, much shorter than the keel; claw short, ± 1.5 mm long; lamina ± 4 × 3–4 mm, without lobes or callosities, abaxially pubescent along the apex. *Wing petals* oblong, much shorter than the keel, distinctly auriculate; pubescent along the apex; sculpturing in ± 4 rows of intercostal lunae, fading into transcostal lamellae towards the auricle. *Keel petals* broadly oblong, wider towards the obtuse apex, only slightly auriculate; claw ± 3 mm long; lamina 5–6 × ± 3 mm, pubescent on most of the upper half. *Androecium* long and narrow; anthers dimorphic; basifixed anthers oblong, almost twice as long as the small ovoid dorsifixed anthers; carinal anther similar to dorsifixed anthers. *Gynoecium* shortly stipitate; pistil very small, ovoid-oblong, pubescent, with 1 or 2 ovules; style with the basal part straight, broad and pubescent, the upper part short, slender, glabrous. *Pods* very small, ovoid, ± as long as the calyx, 3–3.5 × 2–2.5 mm, shortly stipitate, compressed (not inflated), densely pubescent, inde-



FIGURE 7.—*Lotononis esterhuyseniana*. A, flowering twig, showing the racemose inflorescence and a leaf in adaxial view; B, leaf and stipule in abaxial view; C, calyx opened out with the upper lobes to the left; D, standard petal; E, wing petal; F, keel petal; G, pistil. H1, H2 & H3, pods: H1, in longitudinal section, showing the seeds; H2, in lateral view; H3, in top view. I1, I2 & I3, anthers: I1, long basifixed anther; I2, carinal anther; I3, dorsifixed anther. J1 & J2, bracts; K, seed, showing the almost smooth surface; L, flower in lateral view. All from Esterhuysen 2934l. Scales in mm.

TABLE 1.—Similarities and differences between *L. esterhuyseniana* and various other groups of the genus *Lotononis*

	<i>L. esterhuyseniana</i>	Section <i>Lipozygis</i> <i>L. pentaphylla</i> group	Section <i>Leobordea</i>	Section <i>Leptis</i> <i>L. mucronata</i> group
Habit	annual	annual	annual	perennial
Inflorescence	racemose	capitate	racemose to 1-flowered	racemose to 1-flowered
Pedice	present	absent	present or when rarely absent, then the inflorescence 1-flowered	present
Leaf type	invariably 3-digitate	often 5-digitate	invariably 3-digitate	invariably 3-digitate
Leaf arrangement of flowering twigs	alternate	alternate	opposite	alternate
Pod:				
size	± as long as the calyx	very small, included within the calyx	as long or longer than the calyx	as long or longer than the calyx
shape	compressed	turgid	slightly turgid	slightly turgid
dehiscence	indehiscent?	indehiscent	dehiscent or tardily dehiscent	dehiscent or tardily dehiscent
Ovule number	1 or 2	2 to 12	6 to 15	4 to 18
Seed number	1 or 2	2 to 5	4 to 9	2 to 16
Calyx:				
shape	not inflated	inflated	rarely inflated	not inflated
carinal lobe	shorter than upper four lobes	not shorter	shorter than upper four lobes	not shorter
Standard:				
shape	suborbicular	oblong or suborbicular	oblong	oblong
length	much shorter than the keel	as long as the keel, rarely much shorter	usually much shorter than the keel	as long as the keel
Distribution	south-western Cape	western coastal areas of the Cape Province	Karoo, Namibia and northwards to Pakistan	eastern parts of southern Africa

hiscent (?); upper suture minutely verrucose, 1 or 2-seeded. *Seeds* suborbicular, $\pm 1,2$ mm in diameter, testa pale orange-brown, sparsely and minutely tuberculate (Figure 7).

L. esterhuyseniana is a distinct species with no obvious affinities. It is similar to *L. platycarpa* (Viv.) Pichi-Serm. and other species of the section *Leobordea* but differs from these in the alternate arrangement of the leaves on flowering twigs and also in the much smaller number of ovules (more than five in section *Leobordea*). It is also similar to *L. laticeps* B-E. van Wyk and other species of the *L. pentaphylla* group (section *Lipozygis*), but differs from these in the racemose inflorescence (not capitate), the small carinal lobe of the calyx, the larger and compressed pods and in the calyx, which is not inflated and which does not enclose the pod at maturity. It also resembles *L. microphylla* Harv. (section *Leptis*) but differs from this species in the annual habit, the calyx structure, the shape and length of the standard petal and the small number of ovules.

The geographical distribution of *L. esterhuyseniana* supports the suggested affinity with the *L. pentaphylla* group (presently section *Lipozygis*) and the section *Leobordea* rather than with the section *Leptis*. The single known locality is shown in Figure 8.

CAPE.—3219 (Wuppertal): Ceres District, Stompiesvlei, Swartuggens (—DC), *Esterhuysen 2934l* (BOL, holo.; C, K, MO, iso.).

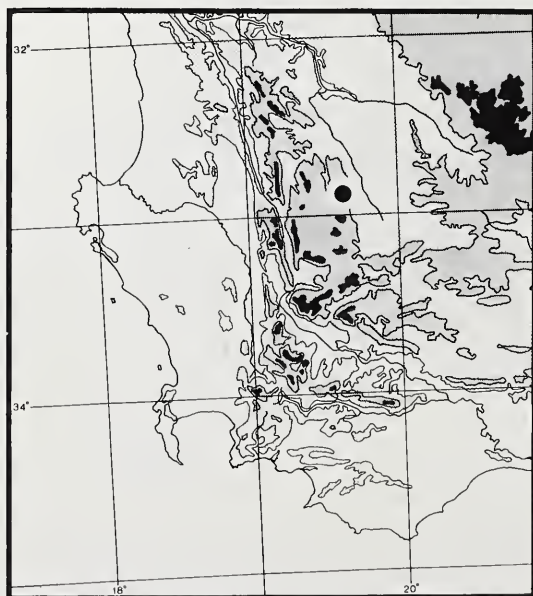


FIGURE 8.—The known geographical distribution of *Lotononis esterhuyseniana*.

ACKNOWLEDGEMENTS

I thank Dr H. F. Glen (National Botanical Institute, Pretoria) for the Latin translation and the directors and staff of the cited herbaria for the loan of specimens. The taxonomic study of *Lotononis* is a registered Ph. D. project at the University of Cape Town.

REFERENCE

VAN WYK, B-E. 1989. Studies in the genus *Lotononis* (Crotalariaeae, Fabaceae). VIII. A new species of the *L. corymbosa* group and notes on the taxonomy of the section *Lipozygis*. *South African Journal of Botany* 55: 528–532.

B-E. VAN WYK*

* Department of Botany, Rand Afrikaans University, P. O. Box 524, Johannesburg 2000.

MS. received: 1989.04.12.

STUDIES IN THE GENUS *LOTONONIS* (CROTALARIEAE). II. A NEW SPECIES OF THE SECTION *LEOBORDEA* FROM NORTH-WESTERN NAMIBIA

INTRODUCTION

The section *Leobordea* (Del.) Benth. is geographically the most widespread section of *Lotononis* (DC.) Eckl. & Zeyh. *L. platycarpa* (Viv.) Pichi-Serm. occurs throughout Africa and eastwards to Pakistan but the other species of the section are all restricted to southern Africa.

Bentham (1843) listed the small subsessile flowers, the subsessile leaf-opposed inflorescences and the small carinal lobe of the calyx as diagnostic characters for the section, but also mentions the dichotomous branches. Detailed studies of the genus as a whole have shown that the length of the pedicels, the inflorescence structure and the calyx structure are rather variable, and that most of the diagnostic characters of *Leobordea* also occur sporadically in other sections. It is suggested here that the opposite arrangement of leaves on flowering branches is the only reliable character to distinguish *Leobordea* from other sections of *Lotononis*. In the section *Leptis* (Eckl. & Zeyh.) Benth., some leaves may occasionally be subopposite, but the leaves are not invariably opposite as in *Leobordea*. It is important to note that the distinction only applies to flowering nodes. Basal leaves that are formed during the vegetative phase are alternate (also in *Leobordea*). This is true for all species of *Lotononis* except *L. lenticula* (E. Mey.) Benth. (section *Oxydium* Benth.) where the basal nodes (but not the flowering nodes) have opposite leaves.

The new species described below provides an interesting example of convergence in *Leobordea*. Schreiber (1970) confused the species with the superficially similar *L. stipulosa* Bak. f. The many-flowered fascicles of the two species are remarkably similar in appearance due to the presence of large leaflike structures around the base of the inflorescences. In the new species, these are enlarged bracts and not enlarged stipules as in *L. stipulosa*.

***Lotononis bracteosa* B-E. van Wyk, sp. nov. *L. stipulosae* Bak. f. valde affinis sed habitu minori, foliis basalibus oppositis (*L. stipulosa* foliis basalibus alternis), foliolis minoribus, stipularum magnitudine formaque, quae oblongae vel ovatae ad 5×3 mm sunt, inflorescentiam non tegentes (in *L. stipulosa* late cordatae, plerumque valde maiores quam 5×3 mm, inflorescentiam tegentes), differt. Stipulae inflorescentiam subtendentes costam unicum, dum illae *L. stipulosae* venas plures e basi habent. Etiam bracteis 2–4 mm latis, late ellipticis vel obovatis (in *L. stipulosa* infra 2 mm latis, lanceolatis differt).**

L. stipulosa Bak. f. sensu Schreib.: 85 (1970).

TYPE.—Namibia, Outjo District, mountains 14 miles [22,4 km] east of Torra Bay, Giess, Volk & Bleissner 6198 (PRE, holo.; M, PRE, WIND, iso.).

Prostrate or procumbent herbaceous annual, often small and short-lived. All mature parts densely pubescent. *Leaves* trifoliolate, densely pubescent on both surfaces. *Leaflets* elliptic to oblanceolate, (4–)6–11(–16) \times (1,5–)2–4(–5) mm; base cuneate; apex acute. *Stipules* broadly oblong to ovate, up to 5×3 mm. *Inflorescences* sessile, umbellate, (2–)5–8(–12)-flowered; bracts conspicuous, broadly elliptic to broadly obovate, 3–4 \times 2–4 mm; apex acute to obtuse, mucronate; base cuneate to cordate. *Flowers* subsessile, 6–8 mm long. *Calyx* not inflated, densely pubescent, with the upper and lateral lobe on either side fused higher up in pairs, the lower lobe slightly narrower and shorter; lobes usually broadly acuminate. *Standard* ovate to oblong, usually shorter than the keel, densely pubescent. *Wing petals* oblong, not much shorter than the keel, pubescent along the lower edge of the lamina; apex obtuse to acute; sculpturing upper basal and upper left central, in 4 rows of intercostal lunae, fading into thin transcostal lamellae towards the auricle. *Keel petals* half oblong-elliptic to oblong, densely pubescent; apex obtuse. *Pods* sessile, scarcely longer than the persistent calyx, broadly obovoid to broadly oblong, only slightly inflated, upper suture \pm smooth, \pm 8-seeded. *Seeds* suborbicular, testa minutely and densely tuberculate (Figure 9).

Closely related to *L. stipulosa* Bak. f. but differs in the smaller habit, the smaller leaflets and in the size and shape of the stipules, which are oblong to ovate, up to 5×3 mm and not covering the inflorescence (broadly cordate, usually much more than 5×3 mm and covering the inflorescences in *L. stipulosa*). The stipules subtending the inflorescences have a single midrib, whereas those of *L. stipulosa* have several veins from the base (Figure 9). It also differs in the 2–4 mm wide, broadly elliptic to obovate bracts (less than 2 mm wide and lanceolate in *L. stipulosa*). The bracts are visible and conspicuous, not hidden by the large and foliaceous stipules as in *L. stipulosa* (Figure 9). There is no vegetative phase as in *L. stipulosa*, where the basal parts of the branches are without inflorescences and the basal leaves alternate. In *L. bracteosa*, inflorescences are formed at the first nodes and the basal leaves are opposite.



FIGURE 9.—*Lotononis bracteosa*. A, habit. B1 & B2, leaves: B1, abaxial view; B2, adaxial view. C, calyx opened out with the upper lobes to the left. D1 & D2, standard petals: D1, abaxial view showing vestiture; D2, adaxial view. E, wing petal; F, keel petal. G1 & G2, pistils: G1, from young flower; G2, from older flower. H1 & H2, pods: H1, top view; H2, pod after dehiscence as viewed from inside, showing funicles. I1, I2 & I3, anthers: I1, small dorsifixed anther; I2, carinal anther; I3, long basifixed anther. J, androecium; K1 to K4, bracts, showing the broadly ovate shape; L, seed in lateral view showing the densely tuberculate surface. *Lotononis stipulosa*. M, leaf from flowering node showing the foliaceous stipules; N1 to N4, bracts, showing the lanceolate shape; O, calyx opened out with the upper lobes to the left. All from Giess, Volk & Bleissner 5772 except A from Giess, Volk & Bleissner 6198; B1, D2, G1, G2, T1 & T2 from Kers 1513; M, N4 & O from Miller 7748; N1 from Davies 715; N2 from Eyles 2020; N3 from Biegel 2923. Scales in mm.

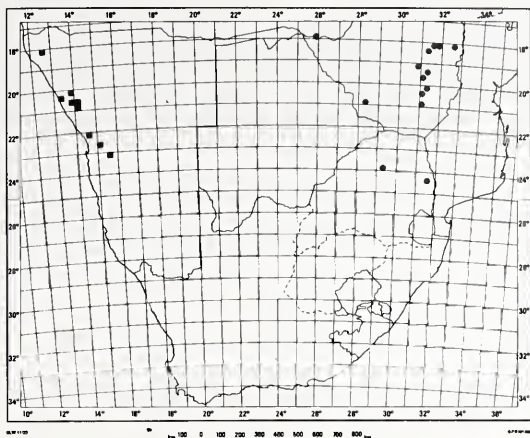


FIGURE 10.—The known geographical distribution of *Lotononis bracteosa*, ■; and *L. stipulosa*, ●.

L. bracteosa is known only from the north-western parts of Namibia, where it appears to be quite common. Figure 10 shows that *L. bracteosa* and *L. stipulosa* are geographically isolated and that the latter does not occur in Namibia.

SWA/NAMIBIA. —1812 (Sanitatas): Kaokoveld, river course 6 miles [9.6 km] south of Orupembe (—BA), *Giess & Leippert* 7524 (M, NBG, PRE, WIND). 2013 (Unjab Mouth): Outjo District, mountain 14 miles [22.4 km] east of Torra Bay (—AD), *Giess, Volk & Bleissner* 6198 (PRE, holo.; M, PRE, WIND, iso.); 23 km south-east of Torra Bay (—AD), *Giess* 8020A (WIND); ± 13 miles [20.8 km] east of Torra Bay (—AD),

Ihlenfeldt, De Winter & Hardy 3229 (M, PRE); 27 miles [43.2 km] south-east of Torra Bay, at Koichab River (—AD), *Nordenstam* 3795 (S); Farm Wêreld-End, 5 miles [8 km] west of house (—BB), *Giess, Volk & Bleissner* 6208 (M, WIND); Farm Wêreld-End, on Petrified Forest to Torra Bay Road, at the coast (—BB), *Kers* 1513 (WIND); Middle-Huab (—DB), *Müller & Loutit* 1153 (WIND). 2014 (Welwitschia): Damaraland, just south of Twyfelfontein (—CA), *Craven* 989 (WIND); Welwitschia, Gai-as (—CC), *Müller & Loutit* 1248 (WIND). 2214 (Swakopmund): Swakopmund District, 22 miles [35.2 km] east of Hentiesbay (—BA), *Giess, Volk & Bleissner* 5772 (M, WIND). 2215 (Trekkopje): Swakop River, Welwitschia flat, along the track from Farm Nordenberg to Swakop River at Tsavischab (—CA), *Kers* 8 (WIND). 2315 (Rostock): Walvis Bay District, Walvis Bay to Kuiseb River to Gamsberg Road, 20 miles [32 km] before the Gorob Mine track (—BA), *Kers* 1287 (WIND); Namib Desert Park, Hotsas (—BA), *Müller* 224 (M, WIND).

ACKNOWLEDGEMENTS

Thanks are due to Dr H. F. Glen (National Botanical Institute, Pretoria) for the Latin translation and the directors and staff of the cited herbaria for the loan of specimens. The taxonomic study of *Lotononis* is a registered Ph. D. project at the University of Cape Town.

REFERENCES

- BENTHAM, G. 1843. Enumeration of Leguminosae, indigenous to southern Asia, and central and southern Africa. *Hooker's London Journal of Botany* 2: 594–613.
- SCHREIBER, A. (1970). Fabaceae. In H. Merxmüller, *Prodromus einer Flora von Südwestafrika* 60. Cramer, Lehre.

B-E. VAN WYK*

* Department of Botany, Rand Afrikaans University, P. O. Box 524, Johannesburg 2000.
MS. received: 1989.04.12.

STUDIES IN THE GENUS LOTONONIS (CROTALARIEAE). 14. THREE NEW SPECIES OF THE SECTIONS TELINA AND POLYLOBIUM

INTRODUCTION

As part of preparatory studies for a synoptic revision of *Lotononis* (DC.) Eckl. & Zeyh., several new species have been described in previous parts of this series. The section *Telina* (E. Mey.) Benth. and the *L. angolensis* group of the section *Polylobium* (Eckl. & Zeyh.) Benth. were treated in parts 2 and 3 respectively (Van Wyk 1988, 1989). Recent studies however, have shown the presence of another two new species of *Telina* and one new species of the *L. angolensis* group. These are described below.

Section *Telina* (E. Mey.) Benth.

Lotononis filiformis B-E. van Wyk, sp. nov., *L. azureae* Eckl. & Zeyh. valde affinis sed habitu longissimo gracili sparsim ramoso, foliolis gracilibus linearibus, lobis calycis oblongis (non triangularibus), fructu minore angustiori et praesertim pube minute strigillosa ramulorum foliorum calycis fructusque (sparsim pilosa in *L. azureae*) differt.

TYPE.—Cape, 3321 (Ladismith): northern slopes of Outeniqua Mountains, between Farms Bonnedale and Woeska (—DD), 14.10.1988, *Vlok* 2030 (PRE, holo.; JRAU, K, MO, NBG, SAAS, STE, iso.).

Very sparse perennial herb, up to 1 m wide. *Branches* long, slender, sparsely leafy, glabrescent, reddish-brown; twigs minutely strigillose. *Leaves* digitately trifoliate; petiole (4–)7–14(–22) mm long; leaflets linear, thick in texture, (4–)8–22(–26) × (0.5–)1–1.5(–2) mm, inconspicuously strigillose on both surfaces. *Stipules* consistently present, single or paired at each node, narrowly lanceolate, (2–)4–8(–10) mm long. *Inflorescences* leaf-opposed, slender, long-pedunculate, 25–120 mm long, invariably single-flowered; bracts small, up to 1.5 mm long; bracteoles absent. *Flowers* relatively large, 8–12 mm long, blue; pedicel 3–8 mm long. *Calyx* 8–10 mm long, subequally lobed, minutely strigillose; lobes narrowly oblong. *Standard* broadly ovate to suborbicular, 7–12 mm long, minutely pubescent on the middle part of the dorsal surface, deep blue with yellow at the base. *Wing petals* oblong, longer than the keel; apex rounded; sculpturing in 2–3 rows of mostly transcostal lunae and lamellae. *Keel petals* semicircular, obtuse, auriculate and pocketed near the base. *Antthers* dimorphic. *Pistil* 9–11 mm long; ovary linear, 6–9 mm long, pubescent; style erect. *Pods* narrowly oblong, 14–20 × 3–4 mm, laterally much inflated, ± 5–8-seeded, minutely strigillose, lower suture sunken, upper suture verrucose, dehiscent. *Seed* suborbicular, ± 2 mm in diameter; testa reddish brown, dark brown or almost black, densely tuberculate; funicles up to 1.2 mm long (Figure 11).

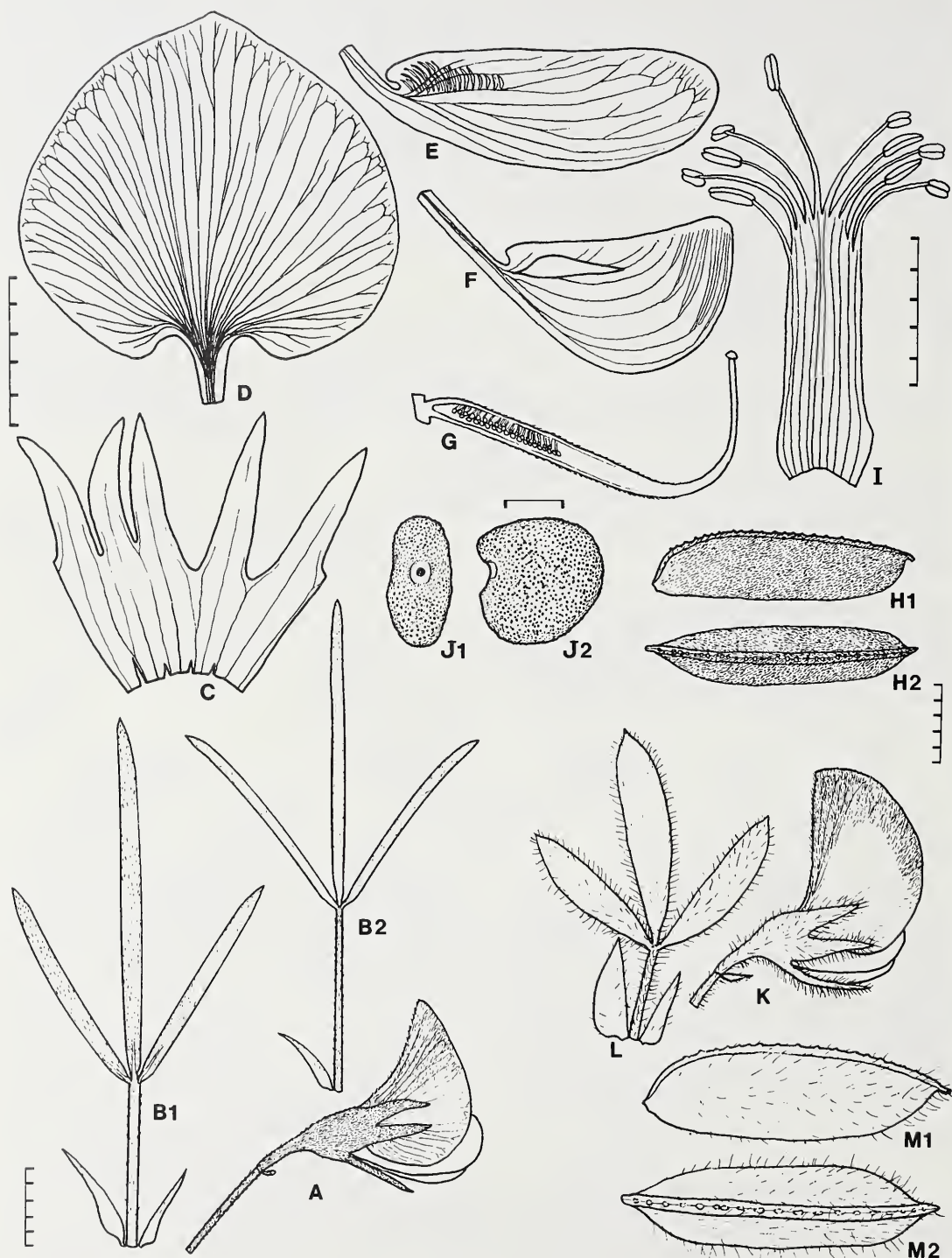


FIGURE 11.—*Lotononis filiformis*. A, flower in lateral view. B1 & B2, leaves, showing the stipules and strigillose vestiture: B1, abaxial view; B2, adaxial view. C, calyx opened out, with the upper lobes to the left, vestiture not shown; D, standard petal; E, wing petal; F, keel petal; G, pistil. H1 & H2, fruit, showing the densely strigillose vestiture and verrucose upper suture: H1, lateral view; H2, top view. I, androecium. J1 & J2, seeds: J1, hilar view; J2, lateral view. *Lotononis azurea* var. *lanceolata*. K, flower in lateral view; L, leaf in adaxial view; M1 & M2, fruit in lateral and top view. All from Van Wyk 2857 except H1, H2, J1 & J2 from Vlok 2030 and K, L, and M from Acocks 13713. Scales in mm.

L. filiformis is very closely related to *L. azurea* Eckl. & Zeyh. but differs in the very long, slender and sparsely branched habit, the slender linear leaflets, the oblong (not triangular) calyx lobes, the smaller narrower fruit and particularly in the minutely strigillose vestiture of the twigs, leaves, calyx and fruit (not sparsely pilose as in *L. azurea*). It is also geographically isolated from the latter and has a more western distribution, known only from the northern slopes of the Outeniqua Mountains (Figure 12). The narrow calyx lobes are very similar to those of *L. azurea* var. *lanceolata* Harv. (based on *Ononis villosa* Thunb.), with which *L. filiformis* has previously been confused (Figure 11). I have examined the Thunberg type specimen of *Ononis villosa*, but the long, sparse and spreading hair covering of the latter is very different from the dense and minutely strigillose vestiture of *L. filiformis*.

I am much indebted to Mr J. H. J. Vlok of Saasveld, George for the opportunity to study the species *in situ*. The almost climbing habit is quite unlike that of any other species of *Lotononis*—the long, slender branches are supported by the surrounding vegetation and when not in flower, the plants are almost invisible.

CAPE.—3321 (Ladismith): Mossel Bay Division, Vryers Berg (—DC), Muir 2042 (BOL); northern slopes of Outeniqua Mountains, between Farms Bonnedale and Woeska (—DD), Vlok 2030 (PRE, holo.; JRAU, K, MO, NBG, SAAS, STE, iso.). 3322 (Oudtshoorn): Oudtshoorn District, Moeras River between Oudtshoorn and Robinson's Pass (—CC), Bolus 11767 (BOL, GRA); lower northern slopes of the Outeniqua Mountains, near Zebrafontein in Doornrivier Wilderness area (—CC), Van Wyk 2857 (JRAU, K, MO, NBG, PRE, STE); 4,2 miles [6,72 km] WNW of Camfer Station (—CD), Acocks 23250 (STE).

***Lotononis complanata* B-E. van Wyk, sp. nov., *L. variae* (E. Mey.) Benth. similis sed habitu foliisque minore, apicibus foliolorum recurvatis, stipulis singularibus (plerumque geminis in quoque nodo in *L. variae*), pube foliorum plus dense strigillosa (foliis \pm glabris in *L. variae*), inflorescentiis semper unifloris (saepae 2- vel pluri-floris in *L. variae*), floribus minoris et praesertim fructu breve oblongo compresso indehiscenti (longiore valde inflato dehiscenti in *L. variae* et speciebus omniis aliis sectionis *Telinae*). Fructus etiam multiseminales ad 30 seminibus (\pm 6–12-seminales in speciebus aliis),**

funiculis sunt usque ad 4 mm longis (usque ad 2 mm in speciebus aliis).

TYPE.—Cape, 3319 (Worcester): Riebeeck-Wes, in Elandsberg Nature Reserve (—AC), 15.06.1988, Vlok 1941 (PRE, holo.; K, NBG, iso.).

Dwarf suffrutescent perennial up to 0,1 m high and 0,2 m wide. Branches slender, procumbent from a thick central rootstock; young twigs densely strigillose. Leaves digitately trifoliate, relatively small, sparsely pubescent, variable in size, those on the main axis with long and slender petioles, those of lateral twigs with the petiole (4–)6–15(–22) mm long; leaflets narrowly to broadly oblanceolate, variable in length, (2–)4–10(–15) \times (1–)2–3(–3,5) mm, adaxial surface glabrous, abaxial surface minutely pubescent; apex acute, recurved. Stipules invariably single at each node, small, narrowly lanceolate, up to 3 mm long. Inflorescences subterminal or leaf-opposed on short lateral branches, invariably single-flowered; peduncle slender, variable in length, (16–45) mm long; bract small, oblong, up to 1 mm long; bracteoles absent. Flowers relatively small, 8–12 mm long, blue; pedicel short, 1–2 mm long. Calyx 5–7 mm long, subequally lobed, minutely pubescent; lobes narrowly triangular. Standard large, suborbicular, 7–11 mm long, with a line of minute hairs dorsally along the middle. Wing petals longer than the keel, oblanceolate; apex obliquely obtuse; sculpturing in 3–4 rows of mostly intercostal lunae and lamellae. Keel petals semicircular, somewhat acute, auriculate and pocketed near base. Anthers dimorphic. Pistil short; ovary oblong, \pm 7 mm long, minutely pubescent; style short, erect. Pods very broadly oblong, 10–21 \times 5–7(–8) mm, compressed, indehiscent, minutely pubescent, apex broad and rounded, 6–30-seeded, upper suture very conspicuously verrucose. Seed kidney-shaped, 1,5 mm in diameter, on very long funicles; funicles up to 4 mm long; testa brown, densely tuberculate (Figure 13).

This species is similar to *L. varia* (E. Mey.) Benth. but differs in the smaller habit and leaves, the recurved leaflet apices, the single stipules (usually paired at each node in *L. varia*), the more densely strigillose vestiture of the leaves (\pm glabrous in *L. varia*), the invariably single-flowered inflorescences (often 2- or more-flowered in *L. varia*), the smaller flowers and particularly in the shortly oblong, compressed and indehiscent fruit (longer, laterally much inflated and dehiscent in *L. varia* and in all other species of the section *Telina*). Differences between the two species are shown in Figure 13. The shape of the pods [*complanatus* = flattened out] is very unusual for the section *Telina* and the tooth-like projections along the upper suture are more strongly developed than in most if not all other species of *Lotononis*. The large number of seeds per pod and the very long funicles are also unique features not found in other species of the section *Telina*.

Only a single collection (without precise locality details) was known prior to the discovery of the species in the Elandsberg Nature Reserve (Figure 12). This discovery is another example of the valuable contributions Mr J. H. J. Vlok has made to the phytogeography of rare Cape

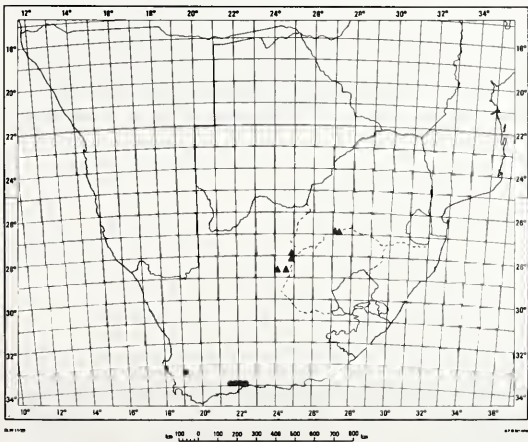


FIGURE 12.—The known geographical distribution of *Lotononis filiformis*, ●; *L. complanata*, ★; and *L. subulata*, ▲.

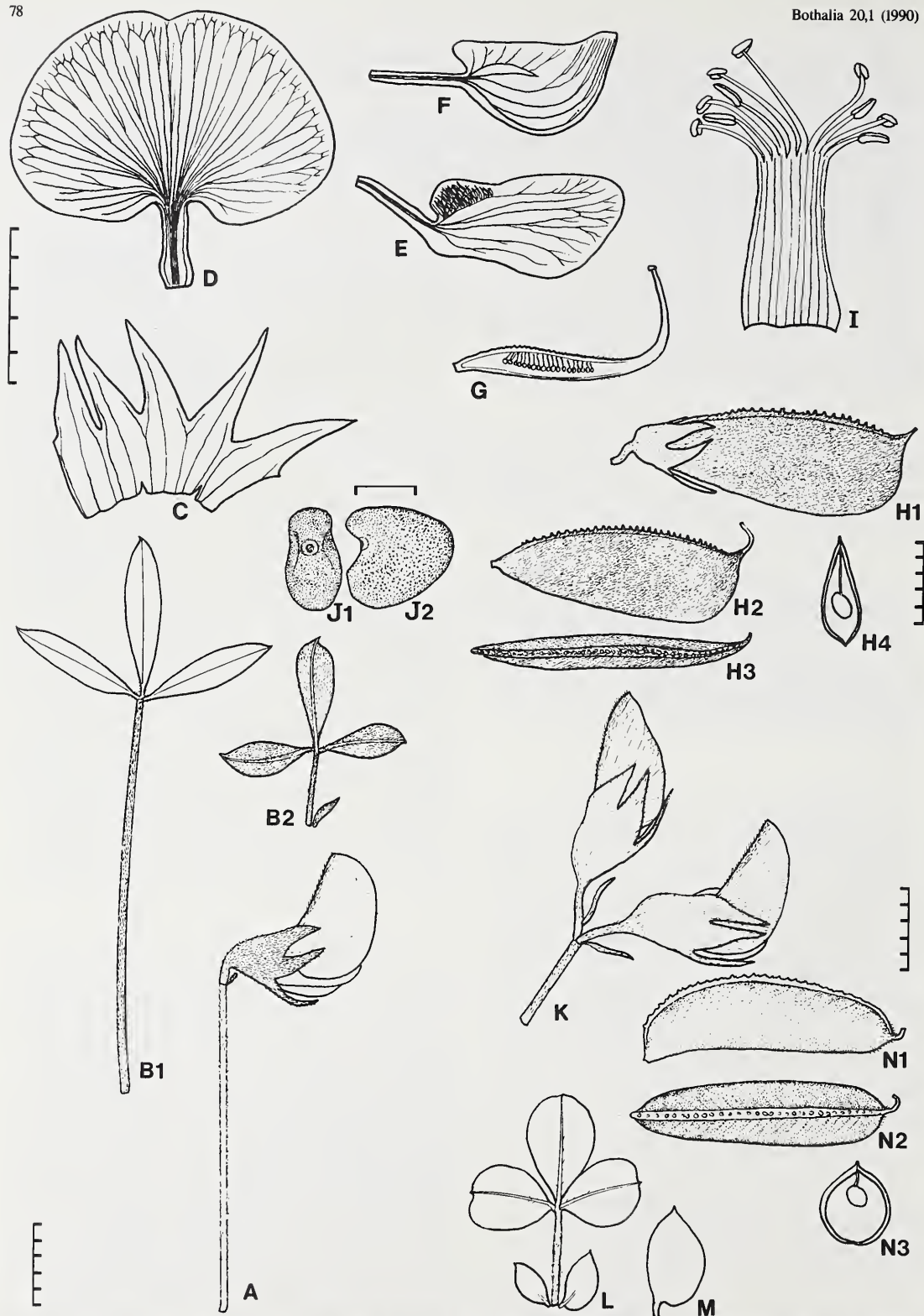


FIGURE 13.—*Lotononis complanata*. A, flower in lateral view. B1 & B2, leaves, showing the slightly recurved leaflet apices and strigillose vestiture: B1, leaf from central branch in adaxial view; B2, leaf from lateral branch in abaxial view. C, calyx opened out, with the upper lobes to the left, vestiture not shown; D, standard petal; E, wing petal; F, keel petal; G, pistil. H1–H4, fruit, showing the distinctive shape, densely strigillose vestiture and verrucose upper suture: H1 & H2, lateral view; H3, top view; H4, transverse section. I, androecium. J1 & J2, seeds: J1, hilar view; J2, lateral view. *Lotononis varia*. K, flowers in lateral view; L, leaf in abaxial view; M, stipule. N1–N3, fruit: N1, lateral view; N2, top view; N3, transverse section. All from Vlok 1941 except H1–H4, J1 & J2 from Van Wyk 2879, K from Esterhuysen 35558, L, M, N1–N3 from Barker 7164. Scales in mm.

legumes. *L. complanata* is known only from one population and it may be worthwhile to assess the population structure from time to time.

CAPE.—3319 (Worcester): Riebeeck-Wes, in Elandsberg Nature Reserve (—AC), 15.06.1988, *Vlok 1941* (PRE, holo.; K, NBG, SAAS, iso.), 07.10.1988, *Van Wyk 2879* (BOL, GRA, JRAU, K, MO, NBG, PRE, S, SAAS, STE). Without precise locality, *Bowie s.n.* (BM, K).

Section *Polylobium* (Eckl. & Zeyh.) Benth. (*L. angolensis* group)

Lotononis subulata B-E. van Wyk, sp. nov., *L. bainesii* Bak. f., *L. listii* Polhill et *L. marlothii* Engl. valde affinis. A *L. bainesii* lobis calycis longis angustis (non late triangularibus), racemis sparsim paucifloris (non subumbellate multifloris) et fructu semper plicato (rare tantum

plicato in *L. bainesii*) differt. A *L. listii* lobis calycis longis angustis (late triangularibus in *L. listii*), inflorescentiis usque ad 4-floris (rare minus quam 6-floris in *L. listii*) et ramulis foliis calyce fructuque distincte pubescentibus (ramulis foliis calyce fructuque \pm glabris in *L. listii*) differt. A *L. marlothii* habitu floresque valde maiore, et fructu valde maiore plicato pubescente (fructu parvo recto glabrescenti in *L. marlothii*) differt.

TYPE.—Transvaal, 2627 (Potchefstroom): Parys, near bridge over Vaal River on Potchefstroom Road (—CD), 01.05.1989, B-E. van Wyk 2884 (PRE, holo.; JRAU, K, MO, S, iso.).

Prostrate herbaceous perennial, up to 1 m in diameter. Branches slender, prostrate, spreading from a woody caudex, often rooting at the nodes to form dense mats,

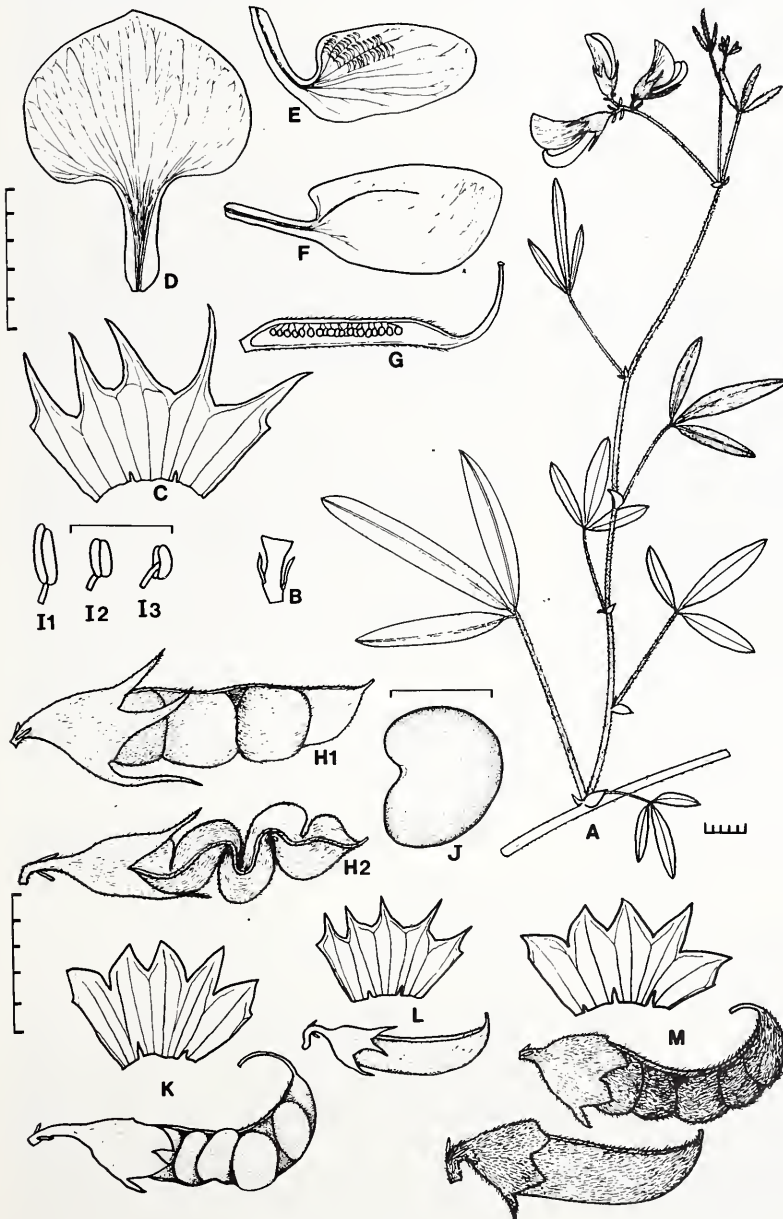


FIGURE 14.—*Lotononis subulata*. A, flowering branch, showing the inflorescence structure, leaves and paired stipules; B, pedicel with bracteoles; C, calyx opened out, with the upper lobes to the left, vestiture not shown; D, standard petal; E, wing petal; F, keel petal; G, pistil. H1 & H2, fruit, showing the distinctive shape and vestiture: H1, lateral view; H2, top view. I1–I3, anthers: I1, basifixed anther; I2, carinal anther; I3, dorsifixed anther. J, seed in lateral view (slightly immature). K, L & M, calyxes and fruit of related species (note differences in the shape of the calyx lobes and fruit): K, *Lotononis listii*; L, *Lotononis marlothii*; M, *Lotononis bainesii*. A–G, I1–I3 from Krynauw 61; H1, H2 & J from Louw 1691. Scales in mm.

thinly and minutely pubescent. *Leaves* digitately trifoliate, very variable in size and shape, adaxially glabrous, abaxially thinly and minutely pubescent, at length glabrescent, somewhat fleshy; petiole slender, (5–)7–24(–60) mm long; leaflets variable in size and shape, linear, narrowly elliptic to oblanceolate, the terminal one (4–)10–28(–36) × (1–)2–5(–7) mm, the lateral ones similar but smaller. *Stipules* up to 5 × 3 mm, dimorphic (the one large and foliaceous, the other similar or more often much smaller), ovate to narrowly lanceolate; base cordate; apex acute; minutely pubescent. *Inflorescences* leaf-opposed or subterminal on lateral branches, slender, 20–120 mm long, sparsely 1–4-flowered; bract linear to narrowly oblanceolate, 2–3 mm long; bracteoles linear, ± 1 mm long. *Flowers* 8–10 mm long, yellow. *Calyx* 4–6 mm long, with the upper and lateral lobe on either side fused higher up in pairs, minutely but distinctly pubescent; lobes very long and narrow, the free part up to 3 mm long. *Standard* orbicular, ± as long as the keel. *Wing petals* oblong, only slightly shorter than the keel. *Keel petals* elliptic; apex obtuse. *Anthers* dimorphic. *Pistil* 12–14 mm long; ovary oblong-linear, 8–10 mm long, pubescent; style short. *Pods* 10–15 × 2–4 mm, invariably folded like a concertina, ± 12-seeded, upper suture ± smooth, indehiscent, distinctly pubescent at maturity. *Seeds* small, ± 1 mm in diameter, testa nearly smooth (Figure 14).

L. subulata is closely related to *L. bainesii* Bak. f., *L. listii* Polhill and *L. marlothii* Engl. and may be confused with these species, particularly when mature fruit are not available. As shown in Figure 14, however, it can easily be distinguished from these species by the shape and size of the calyx alone. The long and narrow calyx lobes have suggested the specific epithet. The inflorescence structure and the shape and vestiture of the fruit are also useful diagnostic characters. *L. subulata* differs from *L. bainesii* in the shape of the calyx lobes (not broadly triangular), the sparsely few-flowered racemes (not subumbellately many-flowered) and in the consistently plicate fruit (only rarely plicate in *L. bainesii*). It can be distinguished from *L. listii* also by the shape of the calyx lobes, the fewer (up to 4) flowers per inflorescence (rarely less than 6-flowered in *L. listii*) and in the distinctly pubescent twigs, leaves, calyx and fruit (twigs, leaves, calyx and fruit ± glabrous in *L. listii*). From *L. marlothii* it differs in the much larger habit and flowers and in the much larger, plicate and pubescent fruit (fruit small, straight and glabrescent in *L. marlothii*).

Compared to its close relatives, *L. subulata* has a much more restricted distribution and has been recorded only from the banks of the Vaal River (south-western Transvaal, eastern Orange Free State and the northern Cape Province, Figure 12). The robust habit and obvious similarities with *L. bainesii* suggest that it may be worthwhile to investigate the agronomic potential of the new species. Despite the similarity between *L. subulata* and *L. listii* and the occurrence of both species at some localities, Wilman (1946: 52) recognized *L. subulata* as a distinct species.

TRANSVAAL.—2627 (Potchefstroom): Potchefstroom District, Scandinavia Drift, bank of Vaal River (–CC), 06.03.1948, Louw 1691 (PRE), 25.04.1979, Krynauw 61 (PRE); Schoemansdrift road, near turn-off to Venterskroon (–CD), 20.02.1979, Ubbink 865 (PRE); Parys (–CD), 04.1907, Potts 553 (BLFU); Parys, near bridge over Vaal River on Potchefstroom Road (–CD), 01.05.1989, B-E. van Wyk 2884 (PRE, holo.; JRAU, K, MO, S, iso.). 2724 (Taung): Internierungslager Andalusia (–DD), 28.12.1941, Giess 103 (M), 05.1942, Volk 228 (WIND).

CAPE.—2824 (Kimberley): bank of Vaal River at Warrenton (–BB), 13.10.1936, Acocks & Hafstrom 1279 (KMG, PRE); Schmidt's Drift, bank of Vaal River (–CA), 03.1935, Wilman s.n. sub KMG 3294 (BOL, KMG); Riverton (–DA), 10.1917, Wilman s.n. sub BOL 15660 (BOL).

ACKNOWLEDGEMENTS

I wish to thank Mr J. H. J. Vlok (Saasveld Forestry Research Centre, George) for his keen interest in the *Lotononis* project and for the valuable material of rare species. The directors and staff of the cited herbaria are thanked for the loan of specimens and Dr H. F. Glen for kindly translating the diagnoses. The taxonomic study of *Lotononis* is a registered Ph. D. project at the University of Cape Town.

REFERENCES

- VAN WYK, B-E. 1988. Studies in the genus *Lotononis* (Crotalariaeae, Fabaceae). III. A new species of the *L. angolensis* group (section Polylobium) from the northern Cape Province. *South African Journal of Botany* 54: 628–630.
- VAN WYK, B-E. 1989. Studies in the genus *Lotononis* (Crotalariaeae, Fabaceae). 2. Three new species of the section *Telina* from the Cape Province. *Bothalia* 19: 1–5.
- WILMAN, A. 1946. *Preliminary checklist of the flowering plants and ferns of Griqualand West*: 52. Deighton Bell, Cambridge.

B-E. VAN WYK*

* Department of Botany, Rand Afrikaans University, P. O. Box 524, Johannesburg 2000.
MS. received: 1989.06.06.

LILIACEAE/ASPHODELACEAE

THE CORRECT AUTHOR CITATIONS OF *ALOE BOWIEA* AND *A. MYRIACANTHA* (ALOOIDEAE)

INTRODUCTION

Available botanical indexes and catalogues indicate a discrepancy regarding the authorship of the names *Aloe bowiea* and *A. myriacantha* (Table 2). These two species were originally described by Haworth (1824, 1827), but in Roemer & Schultes, *Systema vegetabilium*, both were transferred to *Aloe* (Schultes & Schultes 1829).

Monotypic generic status was later suggested for *A. bowiea* as *Chamaealoe africana* (Haw.) Berger (1905) whereas Stapf (1933) transferred *A. myriacantha* to *Leptaloe*. Recently Obermeyer (1973) and Smith (1983) suggested that *C. africana* should best be regarded as a synonym of *Aloe bowiea*. Reynolds (1947) sank *Leptaloe* Stapf under *Aloe* and included *A. myriacantha* in the section *Graminialoe*. The aim of this paper is to establish

TABLE 2. —Comparison of author citations given by a selection of botanical publications for *Aloe bowiea* and *A. myriacantha*, respectively

Reference	Author citation	
	<i>A. bowiea</i>	<i>A. myriacantha</i>
Salm-Dyck (1834, 1836)	Schultes	
Kunth (1843)	Roemer & Schultes	Roemer & Schultes
Baker (1880, 1896)	Schultes f.	Roemer & Schultes
Bentham & Hooker (1883)	Schultes	Schultes
Jackson (1895)	Schultes f.*	Schultes f.
Berger (1905)	Schultes f.	Roemer & Schultes
Berger (1908)	Roemer & Schultes	(Haw.) Roemer & Schultes
Reynolds (1947, 1950, 1954, 1966)		(Haw.) Roemer & Schultes
Jacobsen (1954, 1977)	Schultes*	(Haw.) Roemer & Schultes
Bornman & Hardy (1971)		(Haw.) Roemer & Schultes
Obermeyer (1973)	Roemer & Schultes f.	(Haw.) Roemer & Schultes f.
Jeppe (1977)	Roemer & Schultes	(Haw.) Roemer & Schultes
Reynolds (1982)	Roemer & Schultes f.	(Haw.) Roemer & Schultes
Bond & Goldblatt (1984)	Roemer & Schultes**	
Gibbs Russell <i>et al.</i> (1985)	Roemer & Schultes	(Haw.) Roemer & Schultes

* *Aloe bowiea* incorrectly listed as an orthographic variant, viz. *Aloe bourea*.
** *A. bowiea* incorrectly listed as an orthographic variant, viz. *Aloe bowieae*.

the correct author citations of *Aloe bowiea* and *A. myriacantha*, respectively.

DISCUSSION

After Linnaeus's death in 1778, the botanical part of the editions of the *Systema naturae* was frequently published in amended form as *Systema vegetabilium* (Stafleu & Cowan 1983). The sixteenth edition of *Systema vegetabilium* was published in seven volumes which appeared in print between 1817 and 1830. Volumes 1–4 were authored by Johann Jakob Roemer (1763–1819) and Josef August Schultes (1773–1831); volumes five and six by J.A. Schultes, except for Umbelliferae (6: 315–628) which is by K.P.J. Sprengel, and special entries which are by other authors; and volume seven by J.A. Schultes and Julius Herman Schultes (1804–1840).

Although Roemer died in 1819, Stafleu & Cowan (1983) justifiably suggest that citation of edition 16 (volumes 1–7) of *Systema vegetabilium* should be to 'Roemer and Schultes, *Syst. veg.*' It is, however, clear that Roemer could not have contributed to nomenclatural or taxonomic changes effected in volume seven of *Syst. veg.* since it was published 10 years after his death. Furthermore, on the title page of volume 7,1, the authors are clearly given as Jos. Augusto Schultes and Jul. Herm. Schultes, Roemer not being mentioned. The preface of this part is also attributed to J.A. and J.H. Schultes only.

However, it is insufficient to refer to J.A. Schultes and J.H. Schultes only when citing authority for taxonomic and nomenclatural changes made in volume seven of *Syst. veg.* J.A. Schultes had two sons who had identical christian names, namely Julius Herman (Stafleu & Cowan 1985) and the use of J.H. Schultes or Schultes fil. only as co-author along with J.A. Schultes is therefore ambiguous and incorrect. These two brothers can be distinguished by birth dates, J.H. Schultes I having lived from 1804 to 1840 and J.H. Schultes II from 1820 to 1887. J.A. Schultes, J.H. Schultes (1804–1840) and J.H. Schultes (1820–1887) are abbreviated as Schult., J.H. Schult. and J.H. Schult. II, respectively (Stafleu & Cowan 1985). Since J.H.

Schult. II was only nine years old when *Syst. veg.* 7,1 was published, it is clear that Schult. and J.H. Schult. should be held responsible for new combinations and *nomina nova* which were published in volume seven of *Syst. veg.*

Part one of the latter volume included the treatment of Linnaeus's Class VI Hexandria Monogynia with *Aloe* sensu Linnaeus (1753) being monographed on pp. 631–715. The name *Aloe bowiea* was published here. This species was originally described under the name *Bowiea africana* by Haworth (1824, 1827). The specific epithet *africana* had, however, previously been validly published for a tall-stemmed species of *Aloe* (Miller 1768). For this reason, *B. africana* had to be renamed. *B. myriacantha* Haw., the only other species described in *Bowiea* Haw., was also transferred to *Aloe* in *Syst. veg.* 7,1. Since the specific epithet *myriacantha* had not previously been used in *Aloe*, it was correctly retained. *Aloe bowiea* should therefore be ascribed to Schult. & J.H. Schult. only. In the case of *Aloe myriacantha* the author of the basionym, namely Haworth, should be cited in parentheses followed by Schult. & J.H. Schult., the authors who effected the transfer (Greuter *et al.* 1988, Article 49).

From the above discussion, it is clear that in all the publications listed in Table 2 the author citations of *Aloe bowiea* and *A. myriacantha* are listed incorrectly. These two species should be cited as follows: *Aloe bowiea* Schult. & J.H. Schult.; *Aloe myriacantha* (Haw.) Schult. & J.H. Schult.

ACKNOWLEDGEMENT

I am indebted to Prof. A.E. van Wyk for critically reading the manuscript.

REFERENCES

BAKER, J.G. 1880. A synopsis of Aloineae and Yuccoideae. *Journal of the Linnean Society, Botany* 18: 148–241.
BAKER, J.G. 1896. *Aloe*. In W.T. Thiselton-Dyer, *Flora capensis* 6,2: 302–329. Reeve, London.
BENTHAM, G. & HOOKER, J.D. 1883. *Genera plantarum* 3,2: 776. Reeve, London.

- BERGER, A. 1905. Über die systematische Gliederung der Gattung *Aloe*. *Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie* 36: 42–68. Engelmann, Leipzig.
- BERGER, A. 1908. Liliaceae—Asphodeloideae—Aloineae. In A. Engler, *Das Pflanzenreich* 4.38.3.2 (Heft 33): 120, 166. Engelmann, Leipzig.
- BOND, P. & GOLDBLATT, P. 1984. Plants of the Cape flora. A descriptive catalogue. *Journal of South African Botany* Supplementary Volume 13: 1–455.
- BORNMAN, H. & HARDY, S.D. 1971. *Aloes of the South African veld*. Voortrekkerpers, Johannesburg.
- GIBBS RUSSELL, G.E., REID, C., VAN ROOY, J. & SMOOK, L. 1985. List of species of southern African plants, edn 2, part 1. Cryptogams, gymnosperms, monocotyledons. *Memoirs of the Botanical Survey of South Africa* No. 51.
- GREUTER, W. *et al.* 1988. International Code of Botanical Nomenclature. *Regnum Vegetabile* 118.
- HAWORTH, A.H. 1824. Decas secunda novarum plantarum succulentarum. *Philosophical Magazine* 64: 298–302.
- HAWORTH, A.H. 1827. Description of new succulent plants. *Philosophical Magazine* 67: 120–126.
- JACKSON, B.D. 1895. *Index Kewensis* 1. Clarendon Press, Oxford.
- JACOBSEN, H. 1954. *Handbuch der sukkulenten Pflanzen, Band I, Abrometiella bis Euphorbia*. Gustav Fischer Verlag, Jena.
- JACOBSEN, H. 1977. *Lexicon of succulent plants*, 2nd edn. Blandford Press, Poole.
- JEPPE, B. 1977. *South African aloes*, 2nd edn, 2nd impr. Purnell, Cape Town.
- KUNTH, C.S. 1843. *Enumeratio plantarum*. Part 4. *Enumeratio Asphodelearum*. Sumptibus J.G. Cottae, Stuttgart and Tübingen.
- LINNAEUS, C. 1753. *Species plantarum*, Vol. 1, 1st edn. Impensis Laurentii Salvii, Stockholm.
- MILLER, P. 1768. *The gardener's dictionary*, 8th edn. Rivington, London.
- OBERMEYER, A.A. 1973. *Aloe, Chamaealoe, Haworthia, Astroloba, Poellnitzia and Chorolirion* (Liliaceae). *Bothalia* 11: 119.
- REYNOLDS, G.W. 1947. Genus *Leptaloe* Stapf. Restoration to *Aloe* Linn. *Journal of South African Botany* 13: 99–105.
- REYNOLDS, G.W. 1950. *The aloes of South Africa*. The Trustees of the Aloes of South Africa Book Fund, Johannesburg.
- REYNOLDS, G.W. 1954. *The aloes of Nyasaland*. The Nyasaland Society and African Book Centre of Nyasaland, Blantyre.
- REYNOLDS, G.W. 1966. *The aloes of tropical Africa and Madagascar*. The Trustees, The Aloe Book Fund, Mbabane.
- REYNOLDS, G.W. 1982. *The aloes of South Africa*, 4th edn. Balkema, Cape Town.
- SALM-DYCK, J.M.F.A.H.I. 1834. *Hortus dyckensis, ou, Catalogue des plantes cultivées dans les jardins de Dyck*. Chez Arnz, Düsseldorf.
- SALM-DYCK, J.M.F.A.H.I. 1836. *Monographia generum Aloes et Mesembryanthemi, Aloe bowiea*. Fasc. 1, fig. 24 (Sect. 14. fig. 1). Düsseldorf.
- SCHULTES, J.A. & SCHULTES, J.H. 1829. Classis VI, Hexandria Monogynia Genera, 1417. *Aloe*. In J.J. Roemer & J.A. Schultes, *Systema vegetabilium* 7,1: 631–715. Sumptibus J.G. Cottae, Stuttgartardiae.
- SMITH, G.F. 1983. *Die taksonomiese status van Aloe bowiea Roem. & Schult. f.* Unpublished B.Sc. project, University of Port Elizabeth.
- STAFLEU, F.A. & COWAN, R.S. 1983. *Taxonomic literature* 4: P–Sak, 2nd edn. Bohn, Scheltema and Holkema, Utrecht. (*Regnum Vegetabile* 110).
- STAFLEU, F.A. & COWAN, R.S. 1985. *Taxonomic literature* 5: Sal–Ste, 2nd edn. Bohn, Scheltema and Holkema, Utrecht. (*Regnum Vegetabile* 112).
- STAPF, O. 1933. *Leptaloë albida*. *Botanical Magazine* 156: t.9300.

G.F. SMITH*

*Department of Plant Sciences, Potchefstroom University for C.H.E., Potchefstroom 2520.
MS. received: 1989.06.29.

POACEAE

TWO NEW SPECIES OF *STIPAGROSTIS* (ARISTIDEAE) FROM THE DUNE-NAMIB DESERT, NAMIBIA*Stipagrostis seelyae* De Winter, sp. nov.

Stipagrostis seelyae De Winter, sp. nov., *S. sabulicolae* (Sect. *Stipagrosti*) affinis, sed inter alia inflorescentia brevi ovato-oblonga ramis maturis reflexis, foliis brevioribus curvatis spinescentibus, aristarum basi supra articulum glabra et lemmate non ultra basim aristarum producto differt.

Suffrutex perennis ligneus, plus minusve 1 m altus; culmi basi simplices, sursum multo ramosi et fasciculati; nodi glabri, in culmis principalibus paribus distante et in ramis fasciculatis arcte dispositi. *Foliorum laminae* plerumque 40–70 mm longae, spinescentes, teretes, canaliculatae, curvatae. *Inflorescentia* laxa, foliis superata, 20–50 × 20–30 mm; rami mature reflexi, in fasciculis alternantibus 6–10 disposita. *Spiculae* 11–12 mm longae. *Glumae* inaequales, superiores inferiores superantes. *Lemma* 3-nervatum, tubulosum, aristarum basi articulatum; aristae 3, omnes plumosae, aequales; callus acuminatus, pilosus.

TYPE.—Namibia, 2315 (Rostock): Namib Naukluft Park, Mniszech's Vley, 23°43'S, 15°29'E, 23.10.1985, *Seely 2156* (PRE, holo.; G, K, M, MO, NBG, P, S, WIND, Z). Figure 15.

Stipagrostis seelyae has previously been referred to in literature as *Stipagrostis* sp. cf. *namaquensis* (Nees) Trin.

& Rupr. (Yeaton 1988; Boyer 1989). *S. seelyae* is named after Dr M.K. Seely, Officer in Charge of the CSIR, Namib Research Station at Gobabeb, who has made extensive observations on this species and collected the type material.

Perennial, robust, glabrous suffrutex (Figure 16), ± 1 m high, forming stiffly erect, sparse to dense tufts from short woody rhizomes. *Culms* woody, straw-coloured or purplish, persistent, up to 5 mm in diameter, rigid, erect, unbranched below, fasciculately and much branched above with the branches and spiny leaves forming dense erect clusters. *Nodes* glabrous, approximate in geminate pairs spaced widely apart on the unbranched lower portion of the culms, the lower node of each pair visible, upper covered by the leaf sheath of the lower node; nodes numerous, close together, spaced 2–10 mm apart towards the apex of the culms and hidden by the leaf sheaths. *Leaves* in pairs, 50–140 mm apart on the unbranched culms; spaced 2–10 mm apart towards the ends of the branches. *Leaf sheaths* glabrous, smooth, straw-coloured, basal ones reduced to cataphylls. *Ligule* a dense fringe of very short hairs. *Auricles* inconspicuous, sparsely hairy or glabrous. *Leaf blades* rigid, terete, canaliculate, spinescent, slightly curved, stiffly erect or spreading, (15)40–70(140) × ± 2 mm; glabrous and smooth abaxially; adaxially strongly ribbed, shortly and densely bristly on the ribs.



FIGURE 15. — *Stipagrostis seelyae*. Holotype specimen, Seely 2156 (PRE), showing fasciculate branching pattern, $\times 0.3$. Photo: A. Romanowski.

Inflorescence a somewhat loose terminal panicle, overtopped by the leaves (Figure 17A), 20–50 \times 20–30 mm, glabrous except for the densely woolly points of attachment of one or two of the basal branches; branches 6–10, single or in clusters alternating on the main axis, each cluster consisting of 2–3 branchlets each bearing one to three spikelets; clusters subtended by a swollen pulvinus and reflexed when mature. **Spikelets** one-flowered, 11–12 mm long including the awns, straw-coloured, the lemma below the articulation occasionally purplish (Figure 17B, C). **Glumes** somewhat curved, straw-coloured, firmly chartaceous with thinner margins; lower glume 4.0–4.5 mm long, ovate-lanceate, 3-nerved, the lateral nerves much shorter than the midnerve which does not extend to the apex, apex obtuse, lacerate; upper glume 8–9 mm long, 3-nerved, all the nerves extending nearly to the apex, apex acute. **Lemma** chartaceous, tubular, \pm 6 mm long up to the base of the awns and including the callus; callus densely hairy, acuminate, about 1.5 mm long, the hairs long at the base of the lemma, sharply diminishing in length down to the fine sharp point; articulation \pm 1 mm below the branching point of the awns; awns 3, disarticulating together with the conical hollow apex of the lemma, spreading and finally reflexed when mature, equally developed, about 5 mm long, densely plumose with silvery spreading hairs, plumes lanceate in outline with the apex subobtuse. **Palea** 1.4 mm long, chartaceous, glabrous, two-nerved, the nerves strongly developed but not produced into a distinct keel, apex obtuse to

emarginate, margins inrolled. **Lodicules** 2, 1.3–1.5 mm long, narrowly obovate, one-nerved, membranous and hyaline but subfleshy and denser towards the base. **Stamens** 3; filaments hairlike, elongating at anthesis; anthers \pm 4.5 mm long, yellow, linear. **Pistil** \pm 3 mm long; ovary ovoid, glabrous; styles 2; stigmas plumose, very narrowly oblong in outline. **Caryopsis** narrowly subturbinate, (3)2–3(4) mm long, shallowly grooved adaxially, and rounded abaxially; hilum and embryo about $\frac{1}{3}$ of the length of the grain.

NAMIBIA. — 2315 (Rostock): Namib Naukluft Park, Mnischezi's Vley, eastern edge of Namib dunes immediately south of the Kuiseb River (–CB), 07.12.1983, Seely 2154; 23.10.1985, Seely 2155, 2156 (PRE); 8 km W of Tsondap Vlei (–CD), 30.5.1969, Jensen 238 (PRE); south of Natab (–CA) 18.4.1969, Jensen 170 (PRE). 2415 (Sossusvlei): Sossus Vley (–CB), 29.6.1974, Giess 13433 (PRE, WIND).

Affinities: even though the vegetative and inflorescence characters of *Stipagrostis seelyae* differ fairly strongly from those of *S. sabulicola* (Pilg.) De Winter as set out in the diagnosis, the spikelets show great similarity, both in size and general configuration and *S. sabulicola* is considered to be the only species closely allied to *S. seelyae*. *S. seelyae* is placed in the Section *Stipagrostis* because of the positioning of the articulation near the apex of the lemma. The similarity in habit with *S. namaquensis* can probably be ascribed to convergent adaptation to the arid and sandy habitat occupied by these two species.

Distribution and ecology: Dr Seely summarizes her extensive knowledge of the distribution and ecology of *S. seelyae*, as follows: 'It occurs extensively in the eastern Namib dunes on the middle and upper dune slope. It does not occur in the interdune valleys when these are not sandy



FIGURE 16. — *Stipagrostis seelyae* growing on a sandy dune slope, showing suffrutescent habit. Copy of a colour slide taken by M.K. Seely.

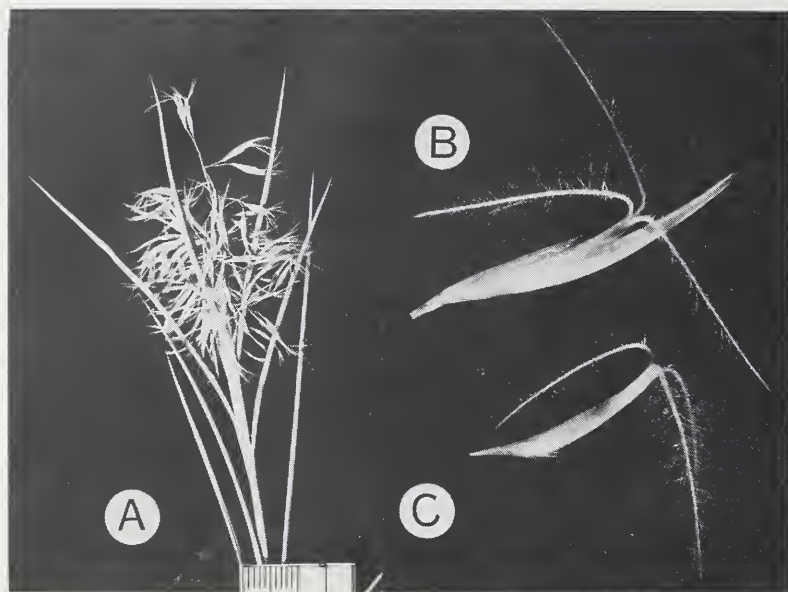


FIGURE 17.—*Stipagrostis seelyae*, Seely 2156 (PRE). A, single inflorescence overtopped by leaves, $\times 0,8$; B, spikelet showing the strongly unequal glumes, the three-awned lemma and spreading, plumose awns, $\times 4,5$; C, lemma showing acute, hairy callus, articulation below branching point of awns and reflexed awns, $\times 4,5$. Photos: A, by A. Romanowski; B, C, by M. Koekemoer.

nor does it occur on the less stable, shifting dune crest. When the full suite of dune grass species is present, *S. gonatostachys* (Pilg.) De Winter and *S. ciliata* (Desf.) De Winter occur on the gravelly interdune and *Centropodia glauca* (Nees) T.A. Cope and *Cladoraphis spinosa* (L.f.) S.M. Phillips on the low to middle dune slope. Usually *Stipagrostis lutescens* (Nees) De Winter occurs in the interdunes when they are sandy and on the base of the dunes themselves. At the very tops of the dunes, particularly in the eastern part of its range, *S. sabulicola* occupies the shifting dune crest. Where *S. seelyae* and *S. lutescens* are absent in the western part of the dune fields, *S. sabulicola* occurs throughout.

This generalized account of the zonation of the grassy elements of the vegetation, places the ecological niche occupied by *S. seelyae* in broad perspective. The composition of the suite of species with which *S. seelyae* is associated, however, does vary from site to site. Yeaton (1988) reports *S. seelyae* (*S. cf. namaquensis* (Nees) Trin. & Rupr.) as associated with *S. sabulicola*, *S. lutescens* and *Centropodia glauca* at Bushman's Circles. On this site *S. seelyae* occupies an intermediate position between *S. sabulicola* on the dune crest and *C. glauca* on the dune base. At the Far East Dune site both *S. seelyae* and *C. glauca* are absent from the suite whereas at Noctivaga Dune the three species present are clearly zoned over the dune slope. *Centropodia glauca* occupies the base of the dune and is replaced upslope by *S. seelyae* on the middune slope, which in turn is replaced at the top of the dune by *S. sabulicola*. Yeaton (1988) points out that species growing where sand movement is rapid, will only be able to survive if they are able to produce sufficient seed before being buried. Plants with strong rhizomes are more successful at establishing in moving sands and their vegetative growth may be stimulated by sand deposition. Moreover, because seeds are rapidly buried in swift-moving sand, plants surviving in such habitats do so predominantly vegetatively. In most of these respects

S. seelyae seems to be extremely well adapted to its sandy, windswept environment. For its known distribution see Figure 18.

This distinct species with its very limited distribution range (Figure 18) occupies an even more specialized niche in the dune habitat than most of the other members of the genus *Stipagrostis* which are restricted to the Namib dune environment. Further intensive study of the relationships, evolution and ecological adaptation of plants of the shifting dunes of the Namib is needed to gain an understanding of the functioning of individual species in the ecosystem.

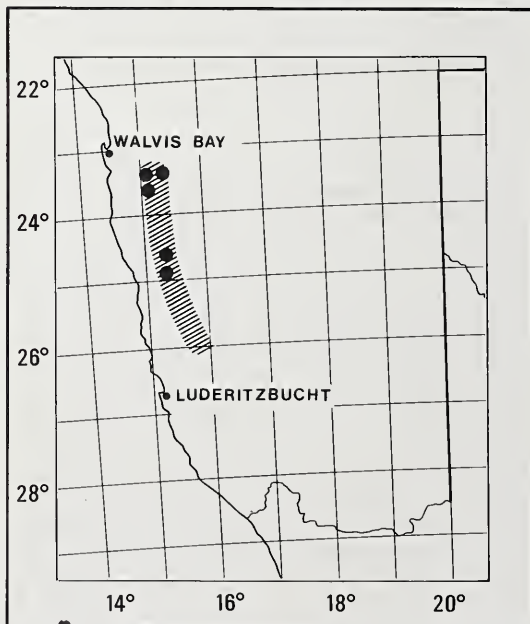


FIGURE 18.—Distribution of *Stipagrostis seelyae*. Dots represent herbarium records; hatching indicates distribution as observed by Seely.

Stipagrostis pellytronis De Winter, sp. nov.

Stipagrostis pellytronis De Winter, sp. nov., *S. hochstetterianae* affinis, sed foliis expansis marginibus cartilagineis; internodiis vaginis basalibus lanatis, callo spiraliter torto bifido differt.

Perennis caespitosa in anno primo florens, tum annum similis. *Vaginae basales foliorum* indumento lanato dense tectae vaginae collo accedentes, persistentes, coronam lanatam perennem formantes. *Nodi* annulum elevatum lanatum tecti. *Foliorum laminae* expansae, nervis marginatis costas cartilagineas formantes. *Inflorescentia* spicata, singula vel plures ex vaginis aphyllis supremis oriens, ex vagines ad maturitatem exserta, ex spiculis ± 9 sessilibus unifloris constans. *Gluma inferior* superiorem longitudine superans. *Lemna* admodum infra medium articulatum; callus ad maturitatem spiraliter tortus, bifidus; aristae 3, tantum centrale longa plumosa, lateralibus multo brevioribus filiformibus glabris.

TYPE.—Namibia, 2315 (Rostock): (—CD) Namib Naukluft Park, Tsondab Vlei, on south-facing scree slope, 28.4.1971, Jensen (Seely) s.n. in *Herb. Giess 11519* (PRE, holo.; G, K, M, MO, NBG, WIND). Figure 20.

The specific epithet refers to the woolly indumentum on the basal leaf sheaths which ends abruptly at the collar of the sheath thus forming a sock-like structure. The Greek Lexicon by Passow gives the following: 'Pellytron, a sort

of bandage or buskin worn by runners next to the foot and ankle.' Elsewhere also referred to as 'a sock'.

Caespitose perennial 300–400 mm high (Figure 19), frequently flowering in the first year and then often very small and resembling an annual. *Culms* single (first year) or several from a perennial base, simple with a single apical inflorescence, or branched from the upper nodes bearing one to several inflorescences on each branch. *Nodes* 3–5 per culm, covered by a dense, raised ring of woolly hairs. *Internodes* (10–)50(–70) mm long, pale yellow, lower ones densely, upper ones gradually more sparsely, covered with woolly crisped hairs, glabrescent. *Leaves* mainly basal, upwards on the culms gradually reduced to the sheaths which envelop the immature inflorescences. *Leaf sheaths* with ± 12 ribs (nerves) abaxially, smooth adaxially, shorter than the internodes; the basal sheaths covered with a dense woolly indumentum which in the perennial plants forms a wool-covered persistent basal crown, upper sheaths glabrous (Figure 21A). *Collar* on the basal leaves densely woolly, sharply demarcated from the glabrous leaf blade; in the upper leaves inconspicuous and glabrous. *Ligule* a straight line of stiff bristles of irregular length. Leaf blade very narrowly lanceate, 3–5 mm wide, expanded, (10–)40 (–110) mm long, firm in texture, glabrous, basal blades well developed, gradually diminishing in size upwards on the culms, absent from the inflorescence sheaths; marginal nerves conspicuous cartilaginous ribs; midrib inconspicuous; other nerves fine, numerous, equally strongly developed.

Inflorescence (Figure 21B) a short spike, borne singly or several together enclosed in apical sheaths on the culms or culm branches, and where more than one spike is present, their subtending sheaths also enclosed by the apical sheath when immature, exserted on a slender rhachis, when mature; ± 40 mm long excluding the awns, each spike composed of ± 9 sessile spikelets, arranged alternately on a slender, strongly ribbed rhachis. *Spikelets* with a single bisexual flower. *Glumes* (Figure 22B) pallid, chartaceous; lower exceeding the upper in length, 12–16 mm long, boat-shaped, lanceate, 3–5-nerved, central nerve reaching the apex, lateral nerves evanescent, tapering to a bifid or lacerate membranous apex; upper glume 10–12 mm long, 3-nerved, central nerve reaching the apex, lateral nerves slightly shorter, boat-shaped; the elongate-truncated, cartilaginous prolongation of the rhachilla or 'callus-placenta' adnate to inside base of the upper glume. *Lemna* chartaceous, tubular, glabrous, including the callus ± 12 mm long, articulated slightly below the middle; callus ± 2.5 mm long, strongly spirally twisted when mature, tapering to a glabrous bifid point, densely covered with short, white antrorse bristles which are 0.5–1.0 mm long at the base of the lemma, diminishing in length towards the apex (Figure 22A), awns 3, disarticulating and falling with the upper half of the lemma; central awn densely plumose with spreading silvery hairs, 25–70 mm long, plume narrowly obovate in outline, tapering to a glabrous or sparsely hairy lower third, apex of plume obtuse; lateral awns glabrous, filiform, 13–25 mm long, spreading. *Palea* a broadly-oblong, semi-chartaceous, truncate scale, ± 1.5 mm long, the nerves represented by two approximate thickened ribs flanking a shallow depression. *Lodicules* 2, ± 1.5 mm long, asymmetrically lanceate, fleshy at the



FIGURE 19.—*Stipagrostis pellytronis*. Perennial tufts growing on gravel derived from Tsondap sandstone. Photo: copy of a colour slide by M. K. Seely.

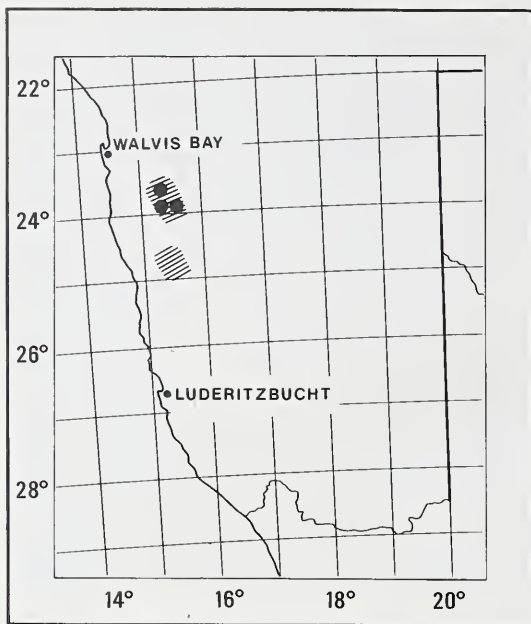


FIGURE 20. — Distribution of *Stipagrostis pellytronis*. Dots represent herbarium records; hatching indicates distribution as observed by Seely.

base, with several indistinct nerves. *Stamens* 3; anthers yellow, linear, ± 7 mm long. *Pistil* ± 6 mm long; ovary glabrous, ovate-oblong; styles 2; stigmas plumose. *Caryopsis* narrowly turbinate, oblanceate in outline,

3–3,5 mm long, smooth, pale brown; hilum a longitudinal line as long as the grain; embryo slightly more than $\frac{1}{3}$ the length of the grain.

NAMIBIA. — 2315 (Rostock): Namib Naukluft Park, Tsondap Vlei (–CD) 23°54'S, 15°24'E, in sand at base of dune near river, 11.4.1971, Hofmeyer 45 (WIND); grass at edge of gravel mountain, 30.5.1969, Jensen (Seely) 236 (PRE); lower reaches of Tsondap River (–DC) 23°54'S, 15°21'E, 22.9.1979, Ward 256 (PRE).

S. pellytronis is unique in the genus because of the very well developed spirally twisted, bifid callus of the lemma. In spite of the unique combination of these features, an affinity with *S. hochstetteriana* (Boeck. ex Hack.) De Winter and especially the variety *secalina*, is proposed for the following reasons: the general configuration of the spikelet and particularly the inversion of the length of the glumes (the lower being longer than the upper), the spiciform inflorescence, the plumose central and the glabrous filiform lateral awns, as well as the position of the inflorescence subtended by sheaths at the apex of the culms. The placing of *S. pellytronis* in the Section *Schistachne* of *Stipagrostis*, the section in which *S. hochstetteriana* is placed, presents no particular difficulty since the allocation of species to the section is based solely on the positioning of the articulation. Both species are articulated near the middle of the lemma. Previous to the discovery of *S. pellytronis*, a bifid callus was known only in *S. obtusa* (Del.) Nees, where both pungent and bifid calli have been recorded in the same species. The unique configuration of the callus is regarded as representing a specific rather than a sectional difference.

The distribution of the species is apparently limited to exposures of Tsondap Sandstone within the central Namib



FIGURE 21. — *Stipagrostis pellytronis*. A, basal part of a first year seedling showing woolly sheaths and annular woolly covering on the nodes, $\times 1$; B, inflorescence, $\times 1$. From the holotype, Jensen (Seely) s.n. in Herb. Giess 11519 (PRE). Photo: A. Romanowski.

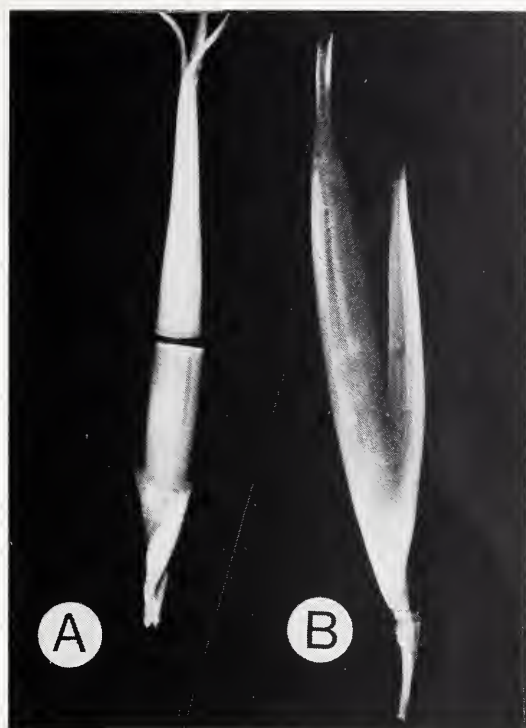


FIGURE 22. — *Stipagrostis pellytronis*. A, lemma showing articulation in middle of the body of the lemma and the spirally twisted, hairy, bifid callus; B, glumes, the lower exceeding the upper; both $\times 7$. From the holotype, *Jensen (Seely) s.n. in Herb. Giess 11519 (PRE)*. Photo: M. Koekemoer.

dune sea. The distribution map (Figure 20) indicates the area in which it has been collected or observed. Its presently known most southerly occurrence is at Sossus Vlei where Tsondap Sandstone outcrops are found. Its distribution further south is uncertain but it may occur in other areas in the eastern part of the dunes, where Tsondap Sandstone outcrops on the surface. The absence of both *S. pellytronis* and *S. seelyae* from the western part of the dune complex cannot be explained. The two species extend in an easterly direction, apparently as far as suitable habitats occur.

ACKNOWLEDGEMENTS

Dr D.B.J. Killick is thanked for the translation of the diagnoses and diagnostic descriptions into Latin. For the information on distribution and ecology of the new species, I am indebted to Dr M.K. Seely who also collected the type material.

REFERENCES

- YEATON, R.I. 1988. Structure and function of the Namib dune grasslands: characteristics of the environmental gradients and species distributions. *Journal of Ecology* 76: 744–758.
BOYER, 1989. Some characteristics of the plant communities of three dunes situated across a climatic gradient in the Namib Desert. *Madoqua* 16: 141–148.

B. DE WINTER*

* National Botanical Institute, Private Bag X101, Pretoria 0001.
MS. received: 1989.12.04.

ASCLEPIADACEAE

CORONA LOBE VARIATION AND THE GENERIC POSITION OF *ASCLEPIAS MACRA*

INTRODUCTION

Generic concepts in parts of the tribe Asclepiadeae have in the past varied greatly. This was partly due to a lack of insight into the evolutionary trends underlying the variation seen in coronal morphology in the tribe.

Baillon (1890), unable to establish well circumscribed genera in the tribe Asclepiadeae, sank most of the African members into one large super-genus to which he applied the name *Asclepias*. N.E. Brown (1902, 1907–1909) had a better understanding of the variation he encountered and produced a workable classification that has served us well for over 80 years. He relied heavily on corona lobe morphology and genera were often separated from each other on single characteristics. In Brown's system *Asclepias* was distinguished from all other genera in the tribe solely on the possession of a corona lobe sinus. Recent work in *Asclepias* sensu N.E. Brown (Nicholas 1981) has highlighted the fact that distantly related groups have occasionally followed the same evolutionary pathways ending up with coronal characteristics that are analogous rather than homologous. Species with such analogues have in the

past been lumped together into genera that form more or less workable units but do not reflect underlying evolutionary realities or affinities. Three distinct evolutionary trends can be seen in corona lobe morphology: 1, reduction to a blob-like structure. Continuation of this trend leads to the eventual disappearance of the lobe; 2, ornamentation, namely increasing ornamentation by the production of wings and/or proximal, distal and sinal appendages (Figure 23). These can be produced singly, together or in various combinations; 3, saccation or the production of a corona lobe sinus, which may result from the development of wings and/or appendages (Figure 23).

In *Flora capensis* the genus *Pachycarpus* was distinguished from others in the tribe Asclepiadeae by its slipper-like corona lobes that may possess two parallel wings proximally on the upper surface of the keel. In addition, the distal end of the keel may become either extended or ornate.

The species long known as *Asclepias macra* Schltr. was originally described by R. Schlechter in 1895(a) under the name *Gomphocarpus suaveolens* Schltr. Later that same

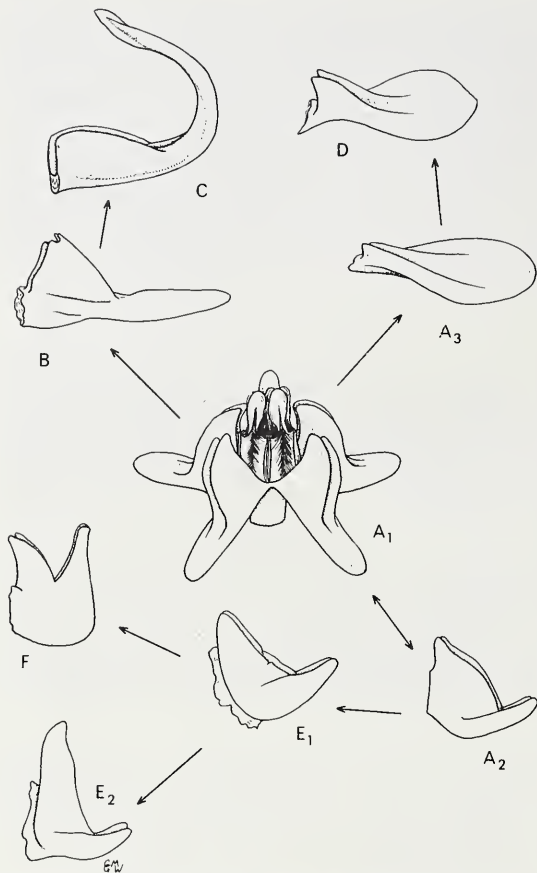


FIGURE 23.—Corona lobe variation in *Pachycarpus* section *Campanulati* showing trends towards both ornamentation and saccation. A1, A2, *P. campanulatus* var. *sutherlandii*, Gerrard 1298, (K). A1, gynostegial column; A2, corona lobe; A3, corona lobe of the type of *P. gerrardii*, now considered synonymous with *P. campanulatus* var. *sutherlandii*, Gerrard 1299, (K). B, *P. campanulatus* var. *campanulatus*, Sanderson s.n., (K). C–F, corona lobe: C, *P. linearis*, Baur 381, (K); D, *P. rostratus*, Haygarth ex Wood 7543, (K); E1, E2, *P. stelliceps*, Bolus 12117, (K); F, *P. suaveolens*, Schlechter 4109, (K). All drawings $\times 3$.

year he sank *Gomphocarpus* into synonymy under *Asclepias* (Schlechter 1895b) and transferred all the known species of *Gomphocarpus*, including *G. suaveolens*, to this genus (Schlechter 1896a). Having done this, Schlechter then noticed that the name *Asclepias suaveolens* had already been used by Leconte and cited by Decaisne in De Candolle's *Prodromus* (1844). He therefore proposed the new name *Asclepias macra* for the taxon (Schlechter 1896b). This latter name was adopted by N.E. Brown in *Flora capensis* and has been used in all subsequent literature. However, Leconte's name was never validly published and according to Decaisne (1844) is no more than an annotation on a herbarium sheet in the Muséum National d'Histoire Naturelle, Phanérogamie, Paris (P). As a result *Gomphocarpus suaveolens* is the correct basionym and *Asclepias macra* should be considered a synonym. Ongoing research into the tribe Asclepiadeae has highlighted the fact that the taxon originally described as *G. suaveolens* should be placed in the genus *Pachycarpus* E. Mey. section *Campanulati* (Schltr.) A. Nicholas & D.J. Goyder.

Brown (1907) excluded *Asclepias suaveolens* from the genus *Pachycarpus* because it possessed a distinct corona lobe sinus, although he did notice its similarity to this genus—'this remarkable species is so exceedingly like *Pachycarpus gerrardii*, N.E. Br., as to be easily mistaken for that plant until the corona is examined'. However, if one examines the corona lobe variation in *Pachycarpus* section *Campanulati*, the progression towards a corona lobe sinus can be clearly seen (Figure 23). *P. suaveolens* represents the end point of the evolutionary trend towards saccation by species in this section. If the plant is viewed in its entirety, there is little doubt that its affinities lie with this section and not with *Asclepias* sensu *Flora capensis* (Table 3). The trend towards sinus production has also occurred in section *Pachycarpus*, a fact hinted at by Bullock (1953), who included species like *P. lineolatus* (Decne.) Bullock and *P. schweinfurthii* (N.E.Br.) Bullock in the genus. These species were previously placed in *Asclepias* because they possess a corona lobe sinus.

Pachycarpus section *Campanulati* is distinguished from all other taxa within the tribe Asclepiadeae by the character combination of linear to narrowly lanceolate leaves with revolute margins, single erect stems that bear nodding inflorescences and campanulate flowers with a hairy ovary.

Obscure characters shared with section *Campanulati*, such as the beak-like shape of the anther wings and the unusual multicellular brown hairs which may sometimes be found on the ovary, also clearly establish the affinity of *P. suaveolens* with this section.

Pachycarpus E. Mey. Section *Campanulati* (Schltr.)

A. Nicholas & D.J. Goyder, comb. nov.

Asclepias L. Section *Campanulatae* Schltr. in Botanische Jahrbücher 21: 9 (1896a). *Pachycarpus* E. Mey. Section *Trichocodon* D.M.N. Smith: 300 (1983); Smith: 399–439 (1988). Type.—*Pachycarpus campanulatus* (Harv.) N.E. Br., chosen here.

Pachycarpus suaveolens (Schltr.) A. Nicholas & D.J.

Goyder, comb. nov.

Gomphocarpus suaveolens Schltr. in Botanische Jahrbücher 20: 38 (1895a). *Asclepias suaveolens* (Schltr.) Schltr.: 9 (1896a). *Asclepias macra* Schltr.: 456 (1896b); N.E. Br.: 670–671 (1907). Types.—Transvaal 2529 (Witbank): Olifants River (–CD), Schlechter 4109 (K!), lecto., chosen here; BM, GRA, NH, PRE! isolecto.). 2530 (Lydenburg): Elandspruitberg (–AA), Schlechter 4006 (syn., not seen by the authors).

DESCRIPTION

Perennial herb. *Rootstock* not seen. *Stem* single, erect to suberect, 205–275(–400) mm high, bifariously strigose, younger parts pilose. *Leaves* erect or slightly spreading, linear to narrowly lanceolate, (45–)65–105 (–152) \times (1,8–)2,5–5,0 mm, apex acute, base minutely truncate (almost minutely auriculate) to attenuate, sparsely hairy, margins revolute; petiole 2,0–4,5 (–7,0) mm long. *Inflorescence* umbelliform, semipendulous to pendulous, terminal, rarely axillary, 1(–3) per plant, 5–10-flowered; peduncles 20–27(–67) mm long. *Flowers* 17–24 \times 9–15 mm; pedicel 15–20 mm long. *Sepals* lanceolate to ovate, (0,4–) 5,0–8,0 \times 1,8–2,8 mm, hirsute. *Corolla* subglobose campanulate, petals fused for $2/3$ their length, 11,5–16,0 \times 7,0–9,5 mm, occasionally with long multicellular brown hairs outside; lobes (3,5–)5,0–7,0 \times 7,0–9,5 mm, apices rounded and reflexed. *Gynostegial*

TABLE 3. —Morphological comparison of *Pachycarpus suaveolens* with *Asclepias sensu Flora capensis* and *Pachycarpus* section *Campanulati*

Characteristic	<i>Asclepias sensu Flora capensis</i>	<i>Pachycarpus suaveolens</i>	Section <i>Campanulati</i>
Stem number	Single to many	Single	Single
Stem orientation	Erect to decumbent	Erect	Erect
Leaf shape	Linear to ovate	Linear	Linear
Inflorescence	Erect to pendulous	Pendulous	Pendulous
Petals	Free almost to the base	Connate for most of their length	Connate for most of their length
Corolla	Cup-shaped or reflexed, never campanulate	Campanulate	Campanulate
Corona lobe sinus	Present	Present	Absent
Ovaries	Glabrous	Hairy	Hairy

stalk 0,5–0,8 mm. *Corona lobes* fused basally, lobes compressed cucullate, 3,2–4,0 × 4,8–5,2(–6,0) mm; appendages more or less level with style apex, proximals usually just over-topping it; proximal appendages broadly falcate, almost unguiform, 1,0–2,0 × 1,5–3,0 mm, distal appendage finger-like, bifid apically with ± 1,3 mm long cleft, 0,7–1,6(–2,4) × (0,8–)1,2–2,0 mm; keel rounded; sinus a central slit, puberulous inside, ± 1,8 mm deep. *Anthers*: anther wings beak-like, 0,6–1,0 × 1,5–2,1 mm; anther appendages tongue-like, 1,3–2,0 × 1,2–1,5 mm, decumbent on the style apex, apex rounded. *Style apex* truncate with a central depression and 5 crenulate, almost flanged outer lobes, whitish, 3,0–4,0 mm in diameter. *Pollinarium*: pollinia golf-club-shaped, 0,5–1,0 × 1,1–1,25 mm; translator arms minutely winged at junction with corpusculum, (0,4–)0,6–0,8 mm long; corpusculum fusiform, 0,14–0,2(–0,3) × 0,2–0,4(–0,6) mm. *Ovaries* covered in long, brown, multicellular hairs. *Fruit & seed* not seen. Figure 24.

TRANSVAAL. —2529 (Witbank): Olifants River (–CD), *Schlechter 4109* (BM, GRA, K, NH, PRE). 2628 (Johannesburg): Dersley Golf course near Geduld (–AB), *Flugge-de-Smit ex Moss 18178* (PRE). 2629 (Bethal): Spitskop, Ermelo (–BD), *Scheepers 15043* (PRE). 2630 (Carolina): near Bosses (–?), *Burnt Davy 2956* (K).

The morphological affinities of *Pachycarpus suaveolens* lie most closely with *P. campanulatus* var. *sutherlandii* N.E. Br. However, it can be distinguished from this and all other taxa in section *Campanulati* by its distinct, centrally placed corona lobe sinus. The key published by Smith (1988) has been revised to include *P. suaveolens* and is presented below.

- 1a Style apex with margins extended laterally beyond or vertically above the anther appendages:
 - 2a Style apex forming 5 lobes which extend horizontally past the anther appendages; appearing stellate from above *P. stelliceps*
 - 2b Style apex extending vertically above the anther appendages, terminating in 5 small erect lobes; never appearing stellate from above *P. rostratus*
- 1b Style apex with margins never extended laterally beyond or vertically above the anther appendages:
 - 3a Anther appendages 5,0–7,0 mm long *P. linearis*
 - 3b Anther appendages 0,5–4,0 mm long:
 - 4a Corona lobe saccate-cucullate without large proximal wings on the adaxial surface of the keel ... *P. suaveolens*
 - 4b Corona lobe slipper-shaped with large proximal wings on the adaxial surface of the keel:
 - 5a Corona lobes 3,0–8,5 mm long. Inflorescences 3–10-flowered *P. campanulatus* var. *sutherlandii*
 - 5b Corona lobes 9,5–17,0 mm long. Inflorescences never more than 5-flowered *P. campanulatus* var. *campanulatus*

Pachycarpus suaveolens is a rarely collected southern Transvaal endemic (Figure 25). Like the other species in section *Campanulati*, this attractive plant is found in annually burnt or cut grasslands. It flowers between December and January and as such appears to have a rather short flowering period. Only the two specimens collected by Rudolf Schlechter have altitudes recorded—these being 2 040 m and 1 460 m. The rootstock, fruit and seeds have neither been recorded nor collected. Flower colour has not been recorded either and it is difficult to tell from the dried specimens what colour they would have been.



FIGURE 24. —*Pachycarpus suaveolens*, *Schlechter 4109*, (K): A, whole plant × 0,5; B, transverse section through leaf showing revolute margins × 3; C, flower with corolla splayed × 1,5; D, gynostegial column showing shape of corona lobes × 2; E, pollinarium × 7,5.



FIGURE 25. — Presently known distribution of *Pachycarpus suaveolens*. Map scale 4 mm = 100 km.

However, it is likely that they are brownish with a hint of green and purple. One dissected flower (*Flugge-de-Smit ex Moss 18178*) showed a pollinium (in situ) from which a mass of pollen tubes had started to germinate, probably

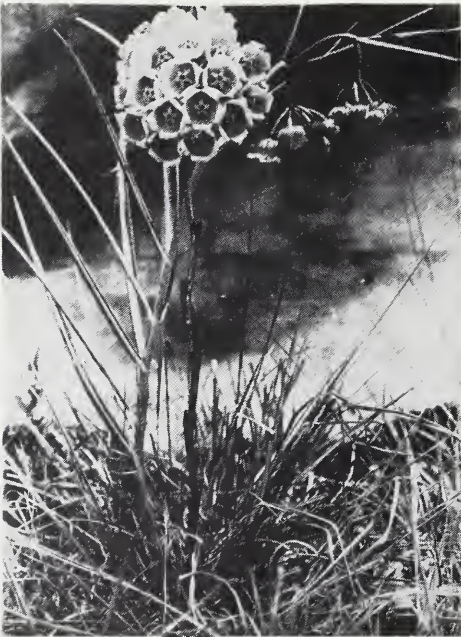


FIGURE 26. — Photograph of *Pachycarpus suaveolens* showing the habit of the plant. Note the single erect stem with its many-flowered, pendulous inflorescences. Photograph of *Flugge-de-Smit ex Moss 18178*, PRE.

evidence of an attempt at self pollination. Had the specimen not fallen prey to a plant press one wonders if this attempt would have been successful.

In the field *P. suaveolens* must look a fine sight with its single, almost erect stem bearing a collection of eight or more densely crowded campanulate flowers in a nodding inflorescence. Figure 26.

ACKNOWLEDGEMENTS

The authors would like to thank the directors of both the Royal Botanic Gardens, Kew and the National Botanical Institute, Pretoria for the opportunity to undertake this work. Thanks also go to all those institutions that allowed us to consult their specimens and use their facilities. Mrs Grey-Wilson (RBG) and Mrs Romanowski (BRI) are thanked for the art work and photography respectively. We are also grateful to Dr Brummitt for his help, and to the referees for their positive contribution.

REFERENCES

- BAILLON, H.E. 1890. *Histoire des plantes* 10: 221–304. Hachette, Paris.
- BROWN, N.E. 1902. Asclepiadeae. In W.T. Thiselton-Dyer, *Flora of tropical Africa* 4,1: 231–503. Lovell Reeves, London.
- BROWN, N.E. 1907–1909. Asclepiadeae. In W.T. Thiselton-Dyer, *Flora capensis* 4,1: 518–1036 & 1129–1133. Lovell Reeves, London.
- BULLOCK, A.A. 1953. Notes on African Asclepiadaceae III. *Kew Bulletin* 1953: 329–362.
- DECAISNE, J. 1844. Asclepiadeae. In A.P. Candolle, A. Candolle & C. Candolle, *Prodromus systematis naturalis regni vegetabilis* 8: 490–665.
- NICHOLAS, A. 1981. *Taxonomic studies in Asclepias L. (Asclepiadeae) with particular reference to the narrow-leaved species in southern Africa*. M.Sc. thesis, University of Natal, Pietermaritzburg.
- SCHLECHTER, R. 1895a. Beiträge zur Kenntnis südafrikanischer Asclepiadeen. *Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie* 20: 1–56.
- SCHLECHTER, R. 1895b. Asclepiadaceae Elliotianae. *Journal of Botany, British and Foreign* 33: 300–307 & 333–339.
- SCHLECHTER, R. 1896a. Die Drège'schen Asclepiadaceen im Ernst Meyer'schen Herbarium. *Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie* 21, Beiblatt 54:: 1–14.
- SCHLECHTER, R. 1896b. Revision of extra-tropical South African Asclepiadaceae. *Journal of Botany, British and Foreign* 34: 311–315, 417–421 & 449–458.
- SMITH, D.M.N. 1983. Section *Trichocodon*. In O.M. Hilliard & B.L. Burtt, Notes on some plants of southern Africa, chiefly from Natal: X. *Notes from the Royal Botanic Garden Edinburgh* 41,2: 300.
- SMITH, D.M.N. 1988. A revision of the genus *Pachycarpus* in southern Africa. *South African Journal of Botany* 54: 399–439.

A. NICHOLAS* and D.J. GOYDER**

* National Botanical Institute, Private Bag X101, Pretoria 0001. Presently: South African Liaison Botanist, Royal Botanic Gardens, Kew, Richmond, Surrey TW9 3AB, England, UK.

** The Herbarium, Royal Botanic Gardens, Kew, Richmond, Surrey TW9 3AB, England, UK.

MS. received: 1989.05.23.

Vegetative morphology and interfire survival strategies in the Cape Fynbos grasses

H.P. LINDER* and R.P. ELLIS**

Keywords: Cape flora, ecology, fire, fynbos, growth form, habit, Poaceae, survival strategies

ABSTRACT

It is shown that there is a wide range of structural variation in the habit of the Arundineae and Ehrharteae of the fynbos of the Cape Floristic Region (Cape Province, South Africa). Structural differences in the bases of the fynbos grasses have been classified into four groups: swollen, knotty tillering, weak and annual. Variation in the position of the innovation buds occurs with one group having basal perennating buds, implying that all the culm material is annual, while the second group has cauline innovation buds, leading to the development of a divaricate perennial herb. The recognition of caducous, mesic (orthophyllous) and sclerophyllous leaf blades is also possible, based on leaf morphology and anatomy. These variations in growth forms allow the classification of the Cape grasses into five guilds adapted for survival in the dense fynbos vegetation that develops between the well-spaced fires in these heathlands. The following guilds have been recognized: competition avoiders that grow on rock ledges and outcrops where competition from shrubby vegetation is reduced; reseeders, that survive the protracted interfire period as seed; geophytes, that survive this period as underground organs; coppicers, that survive as small plants; and competitors, that grow tall by means of cauline innovation buds, and so are able to compete with the shrubby heath vegetation.

UITTREKSEL

Daar word aangetoon dat daar 'n wye reeks strukturele variasie in die groeiwyse van die Arundineae en Ehrharteae van die fynbos van die Kaapse Floristiese Gebied (Kaapprovinsie, Suid-Afrika) bestaan. Strukturele verskille in die basisse van die fynbosgrasse is in vier tipes ingedeel: geswolle, knoesterig stingelsuivormend, swak en eenjarig. Daar bestaan variasie in die posisie van die verjongingsknoppe, met een groep wat basale oorwinteringsknoppe het, wat impliseer dat al die halmmateriaal eenjarig is. Daarteenoor kom die verjongingsknoppe by die tweede groep op die stingel voor, wat aanleiding gee tot die ontwikkeling van 'n uitgespreide meerjarige kruid. Die erkenning van vroegafvallende, mesiese (ortofiele) en sklerofiele blaarskywe is ook moontlik, op grond van die blaarmorfologie en -anatomie. Die Kaapse grasse kan op grond van hierdie variasie in groeivorms in vyf gildes geklassifiseer word wat aangepas is om te oorleef in die digte fynbosplantegroei wat tussen die goedgespaseerde brande in hierdie heideveld ontwikkel. Die volgende gildes word erken: kompetisievermyders wat op rotslyste en klipriwe groei waar kompetisie van struikagtige plantegroei verminder is; hersaaiers wat die langdurige periodes tussen brande as saad oorleef; geofiete wat hierdie periode in die vorm van ondergrondse organe oorleef; stomplotplante wat as klein plante oorleef; en kompeteërs wat deur middel van verjongingslote aan die stingels, hoog uitgroei en sodoende met die struikagtige fynbosplantegroei kan kompeteer.

INTRODUCTION

The southern and south-western parts of the Cape Province of South Africa possess a distinct flora, usually called the Cape Flora (Good 1974; Taylor 1978; Goldblatt 1978; Takhtajan 1986). Goldblatt (1978) delimited the geographical area of this flora, and called it the Cape Floristic Region, with the major vegetation type being 'fynbos'. This region is virtually synonymous with the Fynbos Biome (Rutherford & Westfall 1986). This Cape Flora contrasts with the floras of adjacent biomes both in physiognomy and composition. Floristically, apart from the normally common Asteraceae and Fabaceae, it is characterized by the families Proteaceae, Ericaceae, Iridaceae and Restionaceae, with the Mesembryanthemaceae and Crassulaceae dominating in the more arid regions (Goldblatt 1978; Bond & Goldblatt 1984). The levels of endemism are remarkably high, both at species (68%) and at generic (20%) level. The Poaceae, although generally ranking highly in most floras, is only the 13th largest family in the Cape Floristic Region, even with the

inclusion of the exotic pooids introduced from Europe (Bond & Goldblatt 1984).

The Poaceae of the Cape Floristic Region are poorly understood taxonomically and ecologically. The last complete critical taxonomic revision was by Stapf (1899) for the *Flora capensis*, while Chippindall (1955) produced a guide to their identification. Conert (1970, 1971) revised the generic limits of *Danthonia*, which resulted in several new genera being recognized for the region. Recently Gibbs Russell and Ellis (Gibbs Russell 1987a, b; Ellis 1987a,b; Gibbs Russell & Ellis 1987, 1988) have started a programme on *Ehrharta*, and a co-ordinated programme on the arundinoid grasses of southern Africa is under way. Davidse and Ellis have worked on *Tribolium* and *Prionanthium* (Davidse 1988; Ellis 1989), Barker and Ellis on *Pentameris* and *Pseudopentameris* (Barker 1986; Ellis 1985a,b,c,d, 1986), while Linder & Ellis (1990) have commenced a programme on *Pentaschistis*, *Poagrostis* and allied genera. Linder (in prep.) has reviewed the phytogeographical patterns inherent in the grasses of the Cape Floristic Region, showing that several taxa may help elucidate the origins and evolution of the Cape Flora. The distribution, breeding systems and eco-physiology of the Cape grasses have not been studied, and the only ecological information appears

* Bolus Herbarium, University of Cape Town, Rondebosch, 7700.

** National Botanical Institute/Department of Agricultural Development, Private Bag X101, Pretoria 0001.

MS. received: 1989.05.18.

to be incidental comments in descriptions of vegetation types (i.e. Taylor 1978; Kruger 1979).

The Cape Floristic Region is ecologically very diverse. The climate is essentially Mediterranean, with most of the rain falling in winter, whereas the summers are dry. The amount and seasonal distribution of the precipitation is influenced greatly by the mountain ranges running more or less parallel to the coast. Along the coastal slopes the rainfall is about 1 000 mm p.a., with the drier summers being ameliorated by mist and regular showers. The inland leeward slopes are much drier, with rainfall often less than 250 mm p.a., and with a very hot and dry summer (Fuggle & Ashton 1979). The soils are generally deficient in nutrients, and the combination of dry summers and low soil nutrient status results in slow growth rates for the vegetation as a whole. The vegetation is a shrubland or heathland, from 0.5 to 3 m tall, with a very small herbaceous component, and virtually no annual component (Taylor 1978; Kruger 1979; Campbell 1985). Along the wet coastal ranges the vegetation is dense, with a high basal cover and no bare ground, while along the arid inland slopes the shrubs are well scattered, with ample bare ground which is colonized by annual plants after good winter rains. Although the fynbos vegetation is pyrophytic, fires are spaced well apart, with at least four years between fires, and at most about 40 years, due to the slow biomass build up. The modern average would probably be some 15 years between fires, although it appears likely that in the past the fire cycle could have been much longer (Van Wilgen 1987).

Habit and growth form in the Poaceae have received remarkably little attention in the literature, and consequently there is no generally useful terminology available to describe the vegetative structures. The terms 'tussock' and 'clump' refer to rather similar type structures, and some of the more curious, aerially branching plants have no ready terms. The Cape Poaceae show a remarkable diversity of habits, from the classical caespitose tussock grass to a complex growth form somewhat similar to a divaricate herbaceous plant. These habits appear to be adapted to a range of habitats, both spatial and temporal, in the Cape Floristic Region. They may be highly informative on the ecology and selective restraints operative in the area, and show that these grasses are closely integrated into this unique system, but they have received very little research attention.

Bond & Goldblatt (1984) list almost 200 species of Poaceae for the Cape Floristic Region. Of these, virtually all the endemic species belong to the Arundinoideae in the tribes Arundineae and Ehrharteae. The Pooideae is represented largely by exotic taxa and the Bambusoideae is absent from this biome. Panicoideae and Chloridoideae, although present in fairly large numbers of individuals, have only one endemic species between them, and are scarce in 'typical' fynbos vegetation, but they tend to dominate the grassy fynbos types of the eastern Cape (Campbell 1985; Cowling 1984). The present study is based on the Arundineae, Ehrharteae and Pooideae, indigenous and largely endemic to the Cape Floristic Region. Nomenclature follows that of Gibbs Russell *et al.* (1985), except for *Pentaschistis*, where the nomenclature of Linder & Ellis (1990) is followed.

METHODS

The distributions of the Poaceae species in the Cape Floristic Region were determined from herbarium records using the PRECIS system of the National Botanical Institute, Pretoria (Gibbs Russell 1985a), and the collections of the Bolus Herbarium, University of Cape Town. Whether these grasses were exotic or indigenous was determined following Gibbs Russell *et al.* (1985). Vegetative morphology was also examined on these herbarium specimens. The habit and growth forms of these grasses was classified by recognizing four different base types, two positions for the innovation buds and three different types of leaf morphology. This classification was tested during extensive field work in the spring and summer of 1987, and in the spring of 1988 (August–December). While engaged in these field observations it became apparent that functional correlations exist between the vegetative morphology and the response of these fynbos grasses to fire, and more particularly, to the protracted periods without fire. These long interfire periods in the pyrophytic fynbos vegetation are unusual and the vegetative morphology, together with the fire history data for specific localities led to the recognition of several interfire period survival strategies exhibited by different fynbos grass species. Five different strategies were recognized and this classification was also tested in the field during this period.

Study sites are indicated on Figure 1. The age of the vegetation since the last fire was determined from records of the Chief Directorate of Nature Conservation, from records held in the local offices of Nature Conservation officials, from observations by mountaineers and farmers, and from personal experience of the post-fire successions.

Detailed leaf, culm and base anatomical studies were made from material freshly preserved in FAA in the field, and the vouchers are housed either at PRE (for leaf anatomy) or at BOL (for base and culm anatomy). The results on the anatomy of the bases and culms will be reported separately (Linder, Thompson & Ellis in prep.). Many of the leaf anatomy results have already been published (Ellis 1980a,b, 1982a,b, 1985a–d, 1986, 1987a,b, 1988a,b), whereas studies on *Pentaschistis* leaf anatomy are in preparation (Ellis & Linder in prep.).

Data for a comparison of the Poaceae growth forms of the Cape Floristic Region with those of other biomes was based on species lists available from Gibbs Russell, developed for the analyses of southern African flora and biomes (Gibbs Russell 1985b, 1987c). Growth forms of the savanna and grassland grass species were assigned on the basis of herbarium material. These results are summarized in Figure 2 and on p. 102.

OBSERVATIONS AND DISCUSSION

Base morphology

With the exception of the bamboos, most perennial grasses have herbaceous culms that die back to the base annually and are replaced by shoots arising from axillary basal buds (Gould 1968). The perennial grass 'plant' resulting from several seasons of growth is therefore, made up of several to many lateral shoots initiated at the base.

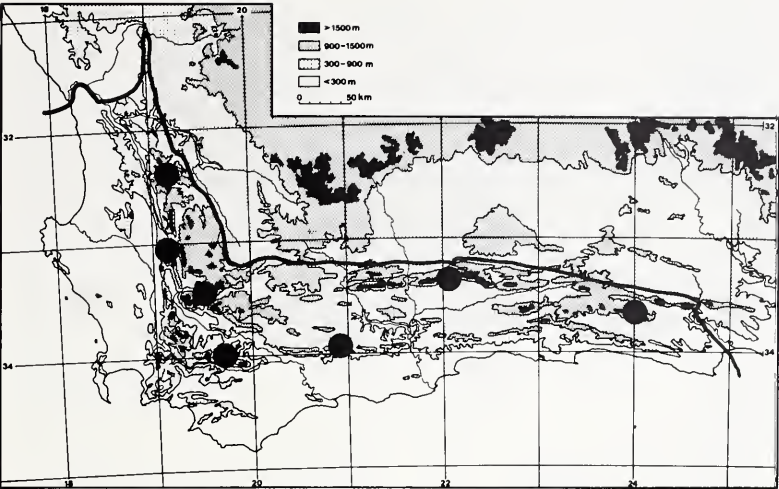


FIGURE 1.—The south-western Cape Province, South Africa. The Cape Floristic Region, as defined by Goldblatt (1978) is outlined by the line, while sample sites are indicated by the dots.

This results in the formation of clones which can reach a spread of 200 m as in *Festuca rubra* (Harberd 1961). By varying the length and thickness of the internodes of this basal portion of the culm, various structures can be developed. In the Cape grasses four different types of base can be distinguished (Figure 3).

1 Bulbous or geophytic bases

The base is modified into a distinct storage organ. This consists of the lowermost culm internode(s) which is generally swollen and tuberous, bulb- or corm-like, and which is usually covered by the fibrous bases of the old leaf sheaths (Burns 1946). The development of these bulbs and corms is rare in the Poaceae (Clayton & Renvoize 1986; Watson & Dallwitz 1988), and occurs in relatively few, unrelated species (Clark & Fisher 1987). In the Cape arundinoids several different structures are found. Bulb-like structures, formed from swollen leaf bases,

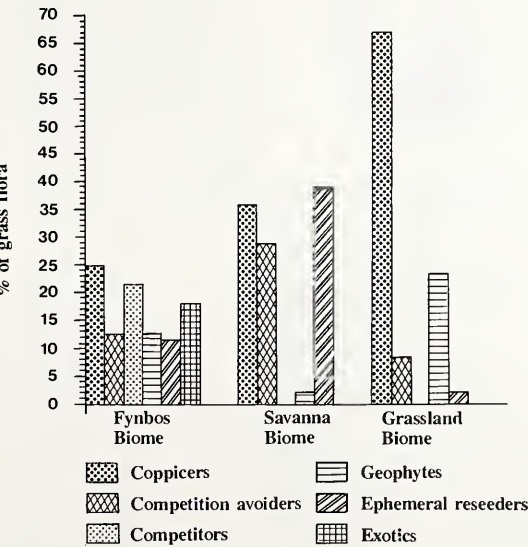


FIGURE 2.—Relative occurrence of growth forms of Poaceae in the Fynbos, Savanna and Grassland Biomes of southern Africa.

occur in *Pentaschistis viscidula*, *P. argentea*, *Merxmuel-lera rufa*, and others. In *Pentaschistis aristidoides* a stout horizontal rhizome is formed, while in *Ehrharta villosa* portions of the stolons become swollen to form pseudobulb-like structures. These structures are deeply sunken below the level of the soil surface, and are often woolly from the densely hairy leaf sheaths, thus protecting the shoot bases from excessive evaporation or temperature changes (Tsvelev 1976). This could also be a protection against fire damage, or a defence against predators. Plants with these bases rarely form dense tufts, usually bearing a single terminal cluster of leaves and few fertile culms. Bulbous bases are unusually common in the Cape arundinoid grasses, examples being *Merxmuellera rufa*, *M. decora*, *Ehrharta capensis*, *E. longifolia*, *E. dura*, *Pentaschistis aristidoides*, *P. viscidula*, *P. argentea* and *P. velutina* in the Arundinoideae and *Festuca scabra* in the Pooideae.

2 Knotty tillering bases

The base consists of tightly aggregated clusters of very short internodes, positioned at or just below the soil surface. The whole structure is usually tangled with old leaf bases, which probably play a protective role for the basal buds. There is no clearly differentiated storage organ. The plants are capable of coppicing from this base after fire, and form tussocks (e.g. *Pentaschistis pallescens*, *P. pyrophila* and *Merxmuellera arundinacea*). If the tillering base is underground, the resulting tussock is often tightly caespitose, as in *P. eriostoma*, *P. pyrophila* and *Merxmuellera stricta*.

3 Weak bases

In this category only a few perennial culms arise from a basal node. The basal internode(s) is not swollen into storage organs, but sometimes associated swollen rhizomes occur (e.g. *Ehrharta setacea* and *E. villosa*). The plants developed from weak bases are usually loosely tufted, short-lived perennials, with branching culms which are decumbent at the base. This stooling (Gould 1968) gives a 'cushion' type of growth. Selected examples of this type of base are *Pentaschistis pallida* form B, *P. densifolia*,



FIGURE 3.—Variation in the base structures of the fynbos arundinoid grasses. A, knotty tillering base, *Pentaschistis pyrophila*; B, geophytic base, *Merxmüllera rufa*; C, disc-like tillering base, *Pentaschistis ampla*; D, weak base, *P. densifolia*; E, annual base, *P. airoides* subsp. *airoides*. All $\times 0.4$.

P. rosea subsp. *rosea*, *P. alticola*, *P. aspera*, *P. acinosa*, *Ehrharta rupestris* and *E. setacea*. These weak bases are very similar to annual bases in that the rooting system is weak, and no thickened woody structures are found.

(*Pentaschistis rosea*, *P. pseudopallescens*), showing the link between these and weak bases.

4 Annual bases

In grasses with annual bases the primary shoot arises directly from the base, and few lateral innovation shoots develop further up the culms. The base never becomes woody. Annual grasses are rare in the mountains on the most nutrient-poor soils (Kruger 1979), but are better diversified on the arid margins of the Cape Floristic Region (*Pentaschistis airoides* subsp. *airoides*, *P. aristifolia*, *P. capillaris*, *Urochlaena pusilla*, *Ehrharta brevifolia* and *E. pusilla*). Biennials and triennials are found in the mountains. These also have the annual type of base

Innovation bud position

The culm is the axis on which the inflorescence as well as the leaves are borne. Each culm is terminated by an inflorescence, and the next season's growth is produced by lateral shoots arising from the nodes. These lateral shoots develop from innovation buds, which are enclosed and protected by the prophyll, a two-keeled modified leaf, which is located adaxially at the base of each lateral shoot (Clark & Fisher 1987). Different growth habits are determined by the position of these perennating buds and their resultant lateral shoots. Two basic variants can be recognized (Figure 4).

1 Basal innovation shoots

Basal innovation shoots develop from buds at the base of the plant. These produce culms which are annual, dying back to the upper tillering node after completion of flowering. All internodes above this node perish, and those below are persistent. This is the common situation in grasses (Gould 1968; Tsvelev 1976), and this tillering produces erect or decumbent lateral culms and the caespitose habit, usually as a result of intravaginal branching. After flowering the culms and leaves senesce, and are eventually replaced by a new basal innovation shoot. These basal innovation shoots are usually associated with knotty tillering bases. Plants with bulbous bases also innovate from the base, but these are deeply subterranean.

Grasses with this type of lateral shoot innovation essentially have an annual above-ground component.

Although generally grass leaves senesce after only a few months, many of the Cape grasses have leaves that persist for at least a year. The underground parts are strongly perennial, and may continue to grow for many years, reaching ages of up to 1000 years in *Festuca ovina* (Harberd 1962). This type of growth form is well adapted to the regular annual or biennial fires characteristic of the subtropical savannas and grasslands. In the Cape Floristic Region examples of this growth form are *Pentaschistis glandulosa*, *P. pyrophila*, *Ehrharta calycina*, and the species listed as having bulbous bases.

2 Cauline innovation shoots

Cauline innovation shoots are produced from nodes higher upon the culms. These culms are generally long-lived, and the above-ground component is perennial, resulting in an 'evergreen' plant. This is an unusual



FIGURE 4. —Variation in the position of the innovation buds in the fynbos arundinoid grasses. A, caulescent innovation buds in a 'competitor', *Pentameris squarrosa*; B, basal innovation buds along creeping rhizomes, *Pentaschistis galpinii*; C, basal innovation buds, forming a caespitose plant, *Pentaschistis curvifolia*; D, innovation buds at the ends of thin erect culms, in an old plant of *Pentaschistis colorata*, forming a cushion. All $\times 0,4$.

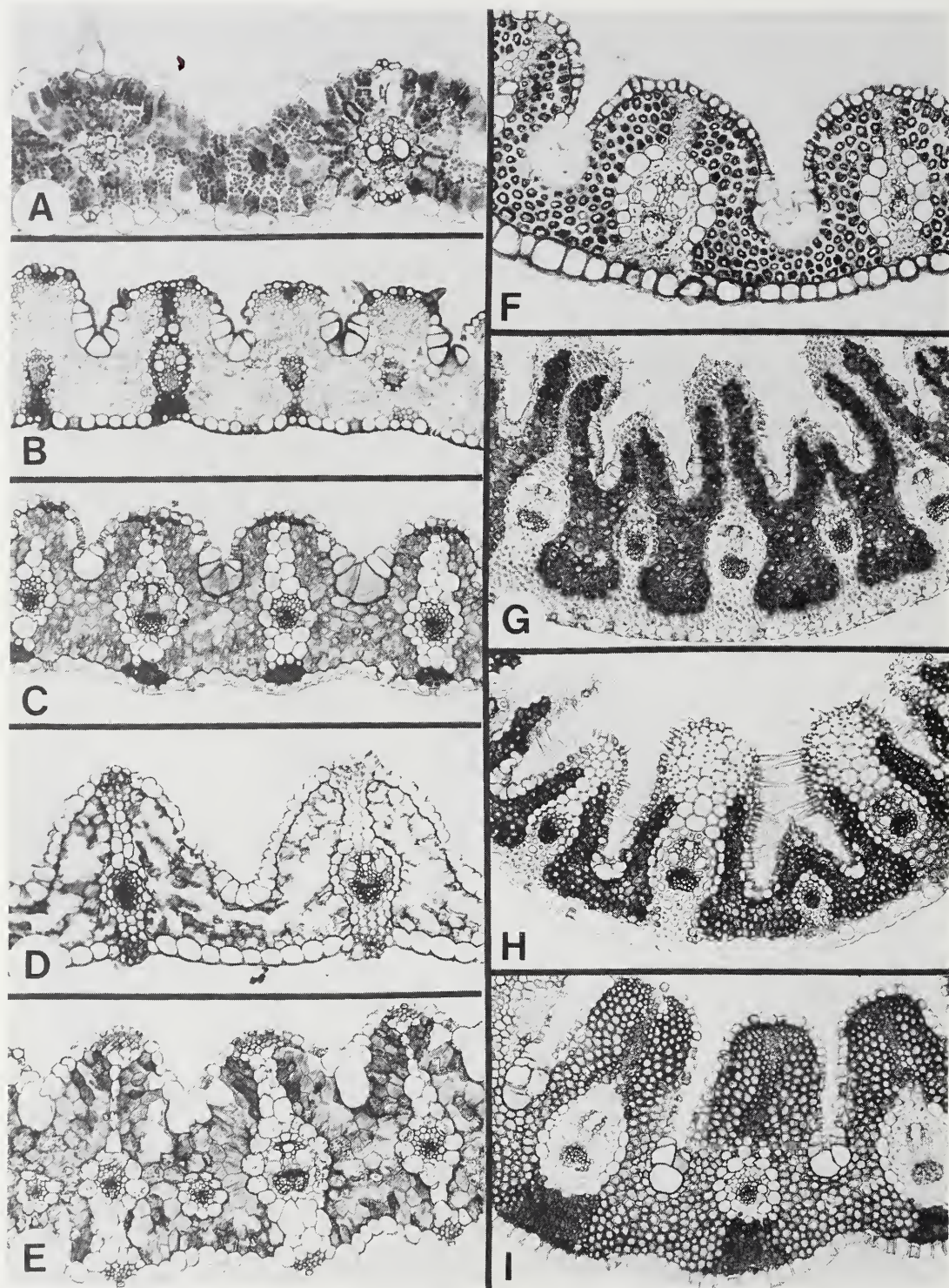


FIGURE 5. —Transverse sections of the leaves of the fynbos arundinoid grasses, illustrating variation in leaf type. A–E, mesic or orthophyllous leaf type; F–I, sclerophyllous leaf type. A, *Ehrharta brevifolia*, with large chlorenchyma cells and intercellular air spaces; B, *Pentstschistis papillosa*, with discrete sclerenchyma girders and strands; C, *Tribolium uniola*, chlorenchyma cells relatively large and angular but air spaces reduced, intermediate type; D, *Festuca scabra*, typical pooid mesic anatomy with very diffuse mesophyll and widely spaced vascular bundles; E, *Chaetobromus involucreatus*, mesic leaf anatomy; F, *Ehrharta setacea*, compact mesophyll of isodiametric cells; G, *Pentstschistis eriostoma*, compact mesophyll, bundles close together and continuous hypodermal sclerenchyma; H, *Pentameris macrocalycina*, compact mesophyll of small cells and few intercellular air spaces, sclerenchyma girders well developed; I, *Merxmüllera rufa*, compact sclerenchyma typical of sclerophyllous leaf type. All $\times 250$.

situation in herbaceous grasses (Gould 1968). Branching culms are very rare in the Pooideae, but there are exceptions in the Andropogoneae (Clayton & Renvoize 1986), Paniceae and particularly the woody Bambuseae (Roshevits 1937). The branching may be profuse with secondary and even tertiary branches. The bases of the species with cauline innovation shoots are either of the weak or of the knotty tillering type. These species also appear to be able to innovate from the base, and so survive fires by coppicing.

Three different patterns appear to occur in the cauline innovating species. In one group, the culms are more or less erect, and the branches well spaced. This results in a 'divaricate herb', which might function in allowing the plant to grow taller than species with only basal innovation shoots (i.e. *Pentaschistis aspera*, *P. acinosa*, *P. scandens*, *Pseudopentameris macrantha*, *P. brachyphylla*, *Pentameris thuarii* and *P. squarrosa*). In the second group the culms are more or less decumbent (at least at the base), and the branches mostly occur near the base of the culms. These plants develop into cushions, often low on the ground. Good Cape examples of this are *Pentaschistis densifolia*, *P. rosea* subsp. *purpurascens* and *P. alticola*. In the third group the plant is initially caespitose, with basal innovation shoots. As the plant becomes older, the innovation shoots are found further from the base of the plant, and a distinct, and sometimes quite long, stem section is found between the woody rootstock and the branching system. This transforms the plant from caespitose to tangled. This pattern is shown most clearly by *P. colorata*, but is also seen in Cape plants of the widespread *Themeda triandra*.

Leaf morphology

The leaf anatomy and morphology of grasses is very important taxonomically, but ecologically three leaf forms may be distinguished in the Cape Floristic Region (Figure 5).

1 Caducous leaf blades

In some species of *Ehrharta* the leaf blade is either early deciduous, or is represented by a small mucro at the apex of the sheath. The leaf sheaths are generally well developed, and together with the culms constitute the photosynthetic organs of the plants. These suffrutescent species are remarkable structural mimics of the Restionaceae.

2 Sclerophyllous leaves

Sclerophyllous leaves (Ellis 1988a) persist for more than one growing season, and possibly even for several years. These are tough, leathery leaves, typically permanently inrolled and filiform or acicular with no abaxial stomata and very compact mesophyll of small isodiametric chlorenchyma cells with minute intercellular air spaces. Sclerenchyma tissue is abundant and may be either lignified or with cellulose walls (Figure 5F–I). This type of leaf appears to be analogous to the sclerophyllous leaves which are characteristic of the vegetation of the Cape Floristic Region, particularly with vegetation growing on the nutrient-deficient sands of the mountains. This type

of blade structure probably helps to 'safeguard' the scarce nutrient resources. All species of *Merxmüllera* and *Pentameris*, as well as many species of *Pentaschistis* have this type of blade.

3 Mesic leaves

Mesic leaves do not persist for more than one growing season. They are typically soft and expanded with abaxial stomata and diffuse mesophyll, and with an extensive air space system. Sclerenchyma tissue is only associated with the vascular bundles as strands or girders (Figure 5A–E). This leaf type is common on soils with better nutrient status. The pooid exotics all have mesic type leaves, and indigenous taxa with mesic leaves (e.g. *Chaetobromus* and *Tribolium*) are lowland taxa associated with intermediate nutrient status soils. However, many species of *Pentaschistis* with mesic leaves are widespread in the Cape mountains. These mesic leaves of the Cape fynbos grasses appear to be analogous to the 'orthophyllous leaves' of Campbell (1985) although the first term refers to habitat and the second to the texture of the leaves.

Interfire survival strategies

The vegetation of the Cape is a shrubby heathland, dominated by Restionaceae, Ericaceae and Proteaceae (Taylor 1978). These fynbos plants are evergreen, generally highly divaricated, and they form a relatively dense shrubbery of 1–3 m tall. The vegetation burns on a variable cycle of between four and 40 years, as vegetation less than four years old rarely has adequate fuel to burn (Van Wilgen 1987). Grasses in general are well adapted to withstand fire, and tropical grasses in particular, become moribund if not burnt regularly. These tropical grasses generally are subject to annual, biennial or triennial fires and their growth forms and habits undoubtedly are determined largely by this regular incidence of fire.

Ecological studies on the vegetation of the Cape Floristic Region have generally emphasized the various methods by which the flora survives the sporadic fynbos fires (e.g. Manders & Cunliffe 1987). However, in the case of the grasses, in addition to surviving the fires themselves, survival in the dense, shrubby fynbos vegetation that develops during the long interfire periods appears to be a major constraint. Immediately after fire, perennial grasses generally are an important component of the regenerating fynbos vegetation, even though this family is virtually absent in mature fynbos prior to burning. After a burn the vegetation gradually becomes denser, generally passing through dominance by the Restionaceae, then the Ericaceae, and finally the Proteaceae (Kruger 1977). This mature, dense vegetation excludes herbaceous species, and so also the grasses. There appear to be five ways in which the grass species of the Cape have responded to this situation.

1 Competition avoiders (Table 1)

These species exploit habitats where taller woody plants cannot grow. Such habitats are either in streams, or in rock crevices and ledges. In these harsh conditions the grasses compete with mosses, a few herbaceous evergreen species and geophytic orchids. The protection from fire offered by these habitats appears to be incidental. Some species are totally restricted to these habitats (e.g. *Pentaschistis*

TABLE 1. — Distribution of growth form and survival strategy in the competition avoider Cape grasses. The vegetation types are approximate and follow Moll *et al.* (1984)

Species	Base type	Innovation buds/shoots	Leaf type	Habitat
<i>Pentaschistis rigidissima acinosa</i>	weak; forming low cushions	cauline	sclerophyllous	Mesic Mountain Fynbos, cliffs and ledges
<i>Pentaschistis capensis</i>				Lower altitudes in streams and waterfalls
<i>Pentaschistis malouinensis</i>		basal		Mesic Mountain Fynbos
<i>Pentaschistis aspera papillosa</i>	weak	cauline only	mesic	Mesic Mountain Fynbos, low altitude
<i>Pentaschistis densifolia pusilla</i> <i>Anthoxanthum dregeanum tongo</i> <i>Brachypodium distachyon</i>	weak; often with rhizomes	basal and cauline		Mesic Mountain Fynbos
<i>Pentaschistis eriostoma</i>	tillering	cauline	sclerophyllous	variable

rigidissima, *P. acinosa*). Other species colonize soil exposed after fire, but soon succumb to the rapidly growing shrubby vegetation. *Pentaschistis densifolia*, *P. malouinensis*, and often *P. eriostoma* fall into the latter category.

Typically, the avoiders are short, cushion forming plants with weak bases, cauline innovation shoots, and sclerophyllous leaves. They are generally restricted to higher altitudes in the mountains (possibly because of the availability of crevices). *Pentaschistis eriostoma* and *P. malouinensis* are both rather widespread, and ecologically flexible. *P. eriostoma*, in particular, can vary from a typical vegetation avoider at higher altitudes, to a classical tussock grass on the arid fringes of the Cape Flora. Some vegetation avoiders deviate from the above description by the possession of mesic leaves, and often also basal innovation shoots. *Pentaschistis densifolia* and *P. pusilla* are arundinoid examples, while most of the 'avoider' pooids also fall into this category (*Anthoxanthum dregeanum*, *A. tongo* and *Brachypodium distachyon*).

The only true graminoid hydrophyte in the Cape is *Pentaschistis capensis* which is found over a wide altitude range, but always growing on rocks and stones in perennial streams, often draped over waterfalls. For this species it is then not clear whether it is avoiding drought or competition from woody vegetation.

2 Reseeders (Table 2)

This group can be defined as those taxa that survive the interfire period as seed. The seed germinates after fire and

grows into annual or short-lived perennial plants that survive for 1–3 years before being forced out by the recovering fynbos vegetation. The grass plants die, leaving their seed till the next fire, which may not be for 25 years, and possibly longer. Whether the species survive as seed banks, or whether they depend on regular dispersal is not clear. If they survive as seed banks, the mechanisms by which the seed is protected for such an extensive period requires attention.

Within the Cape Floristic Region several different reseed strategies exist. True annuals (ephemerals) are found only on the arid fringes of the Region. This includes the West Coast Strandveld (Moll *et al.* 1984) and the Succulent Karoo (Acocks 1988). In these vegetation types soil nutrient levels are higher, but low rainfall prevents the development of a dense basal cover, so that there is ample open ground between the scattered bushes, where annual grasses can grow following adequate rainfall. *Pentaschistis airoides* subsp. *airoides*, *P. aristifolia*, *P. capilaris*, *Urochlaena pusilla*, *Stipa capensis*, *Ehrharta brevifolia*, *E. longiflora*, *E. pusilla*, *Tribolium utriculosa* and *T. echinata* are annual arundinoid species of these arid regions. This is possibly the closest analogue to the true Mediterranean conditions of southern Europe and northern Africa to be found in the winter rainfall region of the Cape. These are not strictly postfire annuals and usually function as interfire annuals as well.

Fynbos postfire reseeders are not true annuals, in that they do not germinate annually, although the plants themselves only grow for a single growing season. *Pentaschistis pseudopallescens*, *P. rosea* and possibly

P. alicola are biennial or triennial, which flower in the second year after fire. They occur above 1 000 m on nutrient-poor and leached soils in the western Cape mountains, and it is possible that these slow development times may be due to the poor soil nutrient status, and the harsh growing conditions. *P. pallida* form B and *P. trisetata* are reseeders which flower in the first year and are found at lower altitudes, in warmer conditions, and on less leached soils. Both groups appear to be facultative perennials, depending on the severity of the summer droughts. If the plant survives the summer, and is not shaded out by the growing vegetation, it may flower for a second year. These species may totally dominate the vegetation after the fires. They all have weak or annual bases, basal innovation shoots and mesic leaves.

3 Geophytes (Table 3)

This group of species behaves like typical geophytes, appearing early in the first winter or spring after fire and flowering profusely soon after commencing growth. By the second post-fire season they are not as prominent and flower less profusely. When they become overshadowed by the regenerating woody vegetation, they appear to survive the protracted interfire period by means of their swollen, subterranean storage organs. It appears as if flowering depletes the base, but that subsequent photosynthesis may replenish the storage products (Hodgkinson & Williams 1983). However, research is still required to follow the cycle of flowering and photosynthate accumulation and translocation, both in these grasses and in analogous groups, such as *Watsonia* in the Iridaceae. The factors controlling flowering and dormancy are not understood. The stored products allow the plants to flower almost

immediately after fire, while the reseeders apparently have to spend the first year accumulating sufficient reserves to support a flowering episode.

The Cape flora is remarkably rich in geophytic grasses. These species tend to dominate areas that are frequently burnt or bush-cut, like fire-breaks. This survival strategy is undoubtedly effective and the methods of overcoming damage by herbivores are poorly understood. These geophytic grasses are probably an important food source for mole-rats, a possibility which needs to be investigated (Lovegrove & Jarvis 1986). Examples are *Pentaschistis viscidula*, *P. argentea*, *P. velutina*, *Merxmuellera rufa*, *M. decora* and *Ehrharta longifolia*. Morphologically, they all have bulbous, subterranean bases, basal innovation shoots and sclerophyllous leaf blades, although these leaves are unusual in having abaxial stomata. *Pentaschistis aristoides* probably also belongs to this group, but is unusual in that the base is developed as a rhizome. *Ehrharta dura*, *E. microlaena*, *E. capensis* and *Festuca scabra* differ from the typical type described above by their mesic leaf anatomy.

4 Coppicers (Table 4)

These species survive the interfire period as persistent, almost dormant, moribund plants. After a fire, they coppice from the base and then flower late in the first spring or summer. The plants then persist above ground without, or with very little, subsequent flowering. They are often evident in the mature vegetation, persisting in the vegetative state as weak moribund tussocks. Presumably, if the interfire period is too long, the plants will eventually die. This form is then usually found at higher

TABLE 2. —Distribution of growth form and survival strategy in the ephemeral reseed Cape grasses. The vegetation types are approximate and follow Moll *et al.* (1984)

Species	Base type	Innovation buds/shoots	Leaf type	Habitat
Pentaschistis trisetata	annual; true annual	basal	mesic	Lowland Fynbos
Pentaschistis pallida form B barbata	weak; short-lived perennials	basal and cauline		
Pentaschistis rosea pseudopallescens pungens	weak; biennials and short-lived perennials			
Pentaschistis airoides subsp. airoides aristifolia capillaris Ehrharta brevifolia delicatula longiflora pusilla triandra Tribolium echinata utriculosa Urochlaena pusilla	annual; true ephemerals		mesic	Succulent Karoo and Strandveld

TABLE 3. — Distribution of growth form and survival strategy in the geophytic Cape grasses. The vegetation types are approximate and follow Moll *et al.* (1984)

Species	Base type	Innovation buds/shoots	Leaf type	Habitat
Pentaschistis aristoides argentea velutina viscidula Merxmuellera decora lupulina rufa Ehrharta longifolia	bulbous; corms	basal	sclerophyllous; with abaxial stomata	Mesic Mountain Fynbos
Ehrharta dura microlaena			mesic	
Ehrharta capensis melicoides Festuca scabra				Mountain Fynbos, lower altitudes

TABLE 4. — Distribution of growth form and survival strategy in the coppicing Cape grasses. The vegetation types are approximate and follow Moll *et al.* (1984)

Species	Base type	Innovation buds/shoots	Leaf type	Habitat
Pentaschistis colorata tortuosa eriosoma ampla Pentameris macrocalycina dregeana obtusifolia	tillering	cauline	sclerophyllous	Mesic Mountain Fynbos
Pentaschistis pyrophila		basal		
Pentaschistis curvifolia malouinensis	weak		mesic	
Ehrharta calycina Pentaschistis rupestris glandulosa				
Pentaschistis pallida form F tomentella				
Pentaschistis cirrhulosa calcicola				
Merxmüllera arundinacea dura cincta stricta	tillering		sclerophyllous	Renosterveld

altitudes where the mature vegetation is not very dense, and where recovery rates are slower.

Pentaschistis pyrophila and *Pentameris obtusifolia* are typical examples utilizing this survival strategy. They have knotty tillering bases, basal innovation shoots and sclerophyllous leaf anatomy. Other species which utilize this strategy, but not exclusively so, are *Pentaschistis colorata*, *P. tortuosa*, *P. eriostoma* and *P. ampla*. *Pentaschistis curvifolia*, *P. malouinensis* and *Ehrharta calycina* may also best be placed into this group, despite their weak bases.

This group overlaps to some extent with other strategies, and is often difficult to define. Many species that form large, persistent tussocks in the more open vegetation at lower altitudes are probably best placed into this group, despite the absence of direct evidence of coppicing after fire. This would include *Pentaschistis rupestris*, *P. pallida* form F, *P. glandulosa*, *P. tomentella*, *P. cirrhulosa*, *P. calicicola*, *Merxmuellera arundinacea* and *M. cincta*. These lower altitude species are generally not shaded out during the interfire period, but this is because of the sparse vegetation in which they grow, rather than any special morphological adaptations that they may have.

5 Competitors (Table 5)

This small, specialized group of grasses appears to be able to compete with low mature fynbos. The plants have

branching culms capable of almost indefinite growth. After flowering has terminated the growth of a culm, a lateral branch continues growth from an upper leaf innovation bud. New leaves are continually formed near the top of the culms with the basal portions being covered by senesced leaf sheaths. These plants may either be tall (up to 2 m) and erect, as in *Pseudopentameris macrantha*, *Pentameris macrocalycina* and *P. thuarii*, or trailing through the vegetation as in *Pentameris squarrosa*, *Pentaschistis scandens* or some of the *Ehrharta* species. These species do not appear to gain in biomass with successive seasons (probably due to limiting nutrients) but gain in height with a reduction in culm diameter and leaf size. In old plants the leaves may be less than 1/4 the length of those produced in the first post-fire season, but the plant may have doubled in height. Flowering is most frequent in the first year after fire and gradually diminishes in later years.

The group of suffrutescent species belonging to the Villosa and Ramosa groups of *Ehrharta* are also competitors, mostly at higher altitudes. These are remarkably similar to the Restionaceae, with reduced, caducous leaves and photosynthetic culms.

Members of this specialized group all have the weak type of base and cauline innovation shoots. The leaves vary from sclerophyllous for most of the higher altitude taxa, or caducous (associated with suffrutescent culms) in some species of *Ehrharta*, to almost mesic in some

TABLE 5.—Distribution of growth form and survival strategy in the competitor Cape grasses. The vegetation types are approximate and follow Moll *et al.* (1984)

Species	Base type	Innovation buds/shoots	Leaf type	Habitat
<i>Ehrharta ramosa</i> <i>rehmannii</i> <i>gigantea</i>	weak	cauline, tall, erect plants	caducous blades	Mountain Fynbos
<i>Ehrharta villosa</i>				Lowland Fynbos
<i>Pentameris dregeana</i> <i>macrocalycina</i> <i>longiglumis</i> <i>obtusifolia</i> <i>Pentaschistis colorata</i> <i>tortuosa</i>			sclerophyllous	Mesic Mountain Fynbos
<i>Pentameris squarrosa</i> <i>thuarii</i> <i>Pseudopentameris macrantha</i> <i>brachyphylla</i>			intermediate	Mesic to wet Mountain Fynbos, lower altitudes
<i>Ehrharta setacea</i> <i>rupestris</i>		cauline, short plants	sclerophyllous	Mountain Fynbos, high altitudes
<i>Ehrharta barbinodis</i>		cauline	intermediate	Succulent Karoo

low-altitude competitors. It is not clear how long these species are capable of persisting in unburnt vegetation, as some show signs of senescence. However, this may depend on the density of the local variant of fynbos. It is this group which shows the greatest deal of convergence with the Restionaceae.

Comparison with other biomes

The spectra of interfire survival strategies found in the Cape are compared in Figure 2 with those of the Grassland and the Savanna Biomes as defined by Gibbs Russell (1985b, 1987c). Direct comparison is difficult, as the enormously different physiography of the different biomes may bias for different growth forms. In addition, the relative frequency of fires in the other biomes suggests that tall and dense interfire vegetation is not a factor, as fire intervals are never as long as 10 years. However, a comparison is still illustrative of how diverse the Cape grasses are in vegetative morphology and ecology in comparison with tropical grasses. From Figure 2 it is abundantly clear that correlated with the extended fire intervals in the fynbos is the occurrence of the 'competitor strategy', which is totally absent from the other biomes. Competition avoiders in the other biomes are all hydrophytes, but in the Cape Floristic Region only one species is a hydrophyte, the rest being lithophytes restricted to ledges and crevices. These are, therefore, true vegetation avoiders, compared with the tropical hydrophytes. Geophytes are remarkably common in the Grassland Biomes as well as the fynbos, and the underground storage of photosynthate in grasses may be worthwhile investigating in more detail. Reseeders are understandably more significant in the Savanna Biome than in both fynbos and grassland where rainfall is usually not limiting. However, the relatively large number of exotic pooids in the fynbos tends to obscure this fact.

CONCLUSIONS

The Poaceae endemic to the fynbos show a range of structural and morphological adaptations which allow them to survive in a variety of niches in the Cape vegetation. Some growth forms allow direct competition with the shrubby Cape Fynbos, while others allow plants to survive the dense interfire vegetation either as seed, as geophytes or as small dormant plants. The models postulated here should contribute to the development of a better understanding of the unique selective forces operative in the fynbos.

The Poaceae in the Cape show a vegetative plasticity not expected from grasses. Unusual growth forms have previously been documented in some arundinoid grasses such as *Steyermarkochloa* (Davidse & Ellis 1985) and *Arundoclaytonia* (Davidse & Ellis 1987) but, apart from the woody bamboos, extensive cauline branching is basically unknown in the family. The arundinoids do have a wide range in habit, from annuals to reed-grasses like *Phragmites* (Renvoize 1981). It is therefore not unexpected that the arundinoids have developed the specialized habits to cope with the Cape Fynbos, whereas the indigenous pooids and other subfamilies have been relatively unsuccessful in the Cape. Exotic pooids, on the other hand, are particularly successful in the Cape but, noticeably, not in the natural flora but in areas of physical disturbance.

REFERENCES

- ACOCKS, J.P.H. 1988. Veld types of South Africa, 3rd edn. *Memoirs of the Botanical Survey of South Africa* No. 57.
- BARKER, N.P. 1986. The shape and ultrastructure of the caryopsis of *Pentameris* and *Pseudopentameris* species (Arundinoideae, Poaceae). *Bothalia* 16: 65–69.
- BOND, P. & GOLDBLATT, P. 1984. Plants of the Cape Flora. *Journal of South African Botany* Supplementary volume No. 13.
- BURNS, W. 1946. Corm and bulb formation in plants, with special reference to the Gramineae. *Transactions and Proceedings of the Botanical Society of Edinburgh* 24: 316–347.
- CAMPBELL, B.M. 1985. A classification of the mountain vegetation of the Fynbos Biome. *Memoirs of the Botanical Survey of South Africa* No. 50: 1–121.
- CHIPPINDALL, L.K.A. 1955. A guide to the identification of grasses in South Africa. In D. Meredith, *The grasses and pastures of South Africa*: 1–527. Central News Agency, Johannesburg.
- CLARK, L.G. & FISHER, J.B. 1987. Vegetative morphology of grasses: shoots and roots. In T.R. Soderstrom *et al.*, *Grass systematics and evolution*: 37–45. Smithsonian Institution Press, Washington DC.
- CLAYTON, W.D. & RENVOIZE, S.A. 1986. Genera graminum. Grasses of the World. *Kew Bulletin*, Additional Series 13: 1–389.
- CONERT, H.J. 1970. *Merxmüllera*, eine neue Gattung der Gramineen. *Senckenbergiana biologica* 51: 129–133.
- CONERT, H.J. 1971. The genus *Danthonia* in Africa. *Mitteilungen aus der Botanischen Staatssammlung, München* 10: 299–308.
- COWLING, R.M. 1984. A syntaxonomic and synecological study in the Humansdorp region of the Fynbos Biome. *Bothalia* 15: 175–227.
- DAVIDSE, G. 1988. A revision of *Prionanthium* (Poaceae: Arundinoideae). *Bothalia* 18: 143–153.
- DAVIDSE, G. & ELLIS, R.P. 1984. *Steyermarkochloa unifolia*, a new genus from Venezuela and Colombia (Poaceae: Arundinoideae: Steyermarkochloaceae). *Annals of the Missouri Botanical Garden* 71: 994–1012.
- DAVIDSE, G. & ELLIS, R.P. 1987. *Arundoclaytonia*, a new genus of Steyermarkochloaceae (Poaceae: Arundinoideae) from Brazil. *Annals of the Missouri Botanical Garden* 74: 479–490.
- ELLIS, R.P. 1980a. Leaf anatomy of the South African Danthonieae (Poaceae). II. *Merxmüllera disticha*. *Bothalia* 13: 185–189.
- ELLIS, R.P. 1980b. Leaf anatomy of the South African Danthonieae (Poaceae). III. *Merxmüllera stricta*. *Bothalia* 13: 191–198.
- ELLIS, R.P. 1982a. Leaf anatomy of the South African Danthonieae (Poaceae). VI. *Merxmüllera arundinacea* and *M. cincta*. *Bothalia* 14: 89–93.
- ELLIS, R.P. 1982b. Leaf anatomy of the South African Danthonieae (Poaceae). VII. *Merxmüllera dura* and *M. rangei*. *Bothalia* 14: 95–99.
- ELLIS, R.P. 1985a. Leaf anatomy of the South African Danthonieae (Poaceae). X. *Pseudopentameris*. *Bothalia* 15: 561–566.
- ELLIS, R.P. 1985b. Leaf anatomy of the South African Danthonieae (Poaceae). XI. *Pentameris longiglumis* and *Pentameris* sp. nov. *Bothalia* 15: 567–571.
- ELLIS, R.P. 1985c. Leaf anatomy of the South African Danthonieae (Poaceae). XII. *Pentameris thurarii*. *Bothalia* 15: 573–578.
- ELLIS, R.P. 1985d. Leaf anatomy of the South African Danthonieae (Poaceae). XIII. *Pentameris macrocalycina* and *P. obtusifolia*. *Bothalia* 15: 579–585.
- ELLIS, R.P. 1986. Leaf anatomy of the South African Danthonieae (Poaceae). XIV. *Pentameris dregeana*. *Bothalia* 16: 235–241.
- ELLIS, R.P. 1987a. Leaf anatomy of the genus *Ehrharta* (Poaceae) in southern Africa: the Setacea group. *Bothalia* 17: 75–89.
- ELLIS, R.P. 1987b. Leaf anatomy of the genus *Ehrharta* (Poaceae) in southern Africa: the Villosa group. *Bothalia* 17: 195–204.
- ELLIS, R.P. 1988a. Leaf anatomy in the South African Danthonieae (Poaceae). XVI. The genus *Urochlaena*. *Bothalia* 18: 101–104.
- ELLIS, R.P. 1988b. Leaf anatomy of the South African Danthonieae (Poaceae). XVII. The genus *Chaetobromus*. *Bothalia* 18: 195–209.
- ELLIS, R.P. 1989. Leaf anatomy of the South African Danthonieae (Poaceae). XIX. The genus *Prionanthium*. *Bothalia* 19: 217–223.
- FUGGLE, R.F. & ASHTON, E.R. 1979. Climate. In J. Day *et al.*, *Fynbos ecology, a preliminary synthesis*: 7–15. South African National Scientific Programmes Report No. 40.
- GIBBS RUSSELL, G.E. 1985a. PRECIS: the National Herbarium's computerized system. *South African Journal of Science* 81: 62–65.
- GIBBS RUSSELL, G.E. 1985b. Analysis of the size and composition of the southern African flora. *Bothalia* 15: 613–628.

- GIBBS RUSSELL, G.E. 1987a. Taxonomy of the genus *Ehrharta* (Poaceae) in southern Africa: the Setacea group. *Bothalia* 17: 67–73.
- GIBBS RUSSELL, G.E. 1987b. Taxonomy of the genus *Ehrharta* (Poaceae) in southern Africa: the Villosa group. *Bothalia* 17: 191–194.
- GIBBS RUSSELL, G.E. 1987c. Preliminary floristic analysis of the major biomes in southern Africa. *Bothalia* 17: 213–227.
- GIBBS RUSSELL, G.E., REID, C., VAN ROOY, J. & SMOOK, L. 1985. List of southern African plants, edn 2, part 1. *Memoirs of the Botanical Survey of South Africa* No. 51: 1–152.
- GIBBS RUSSELL, G.E. & ELLIS, R.P. 1987. Species groups in the genus *Ehrharta* (Poaceae) in southern Africa. *Bothalia* 17: 51–65.
- GIBBS RUSSELL, G.E. & ELLIS, R.P. 1988. Taxonomy and leaf anatomy of the genus *Ehrharta* (Poaceae) in southern Africa: the Dura group. *Bothalia* 18: 165–171.
- GOLDBLATT, P. 1978. An analysis of the flora of southern Africa: its characteristics, relationships, and origins. *Annals of the Missouri Botanical Garden* 65: 369–436.
- GOOD, R. 1974. *The geography of the flowering plants*, edn 4. Longman, London.
- GOULD, F. 1968. *Grass systematics*. McGraw-Hill, New York.
- HARBERD, D.J. 1961. Observations on population structure and longevity of *Festuca rubra*. *New Phytologist* 60: 184–206.
- HARBERD, D.J. 1962. Some observations on natural clones in *Festuca ovina*. *New Phytologist* 61: 85–100.
- HODGKINSON, K.C. & WILLIAMS, O.B. 1983. Adaptation to grazing in forage plants. In J.G. McIvor & R.A. Bray, *Genetic resources of forage plants*: 85–100. C.S.I.R.O., East Melbourne.
- KRUGER, F.J. 1977. A preliminary account of aerial plant biomass in fynbos communities of the Mediterranean-type climate zone of the Cape Province. *Bothalia* 12: 301–307.
- KRUGER, F.J. 1979. Plant ecology. In J. Day *et al.*, *Fynbos ecology: a preliminary synthesis*: 88–126. South African National Scientific Programmes Report No. 40.
- LINDER, H.P. & ELLIS, R.P. 1990. A revision of *Pentastichis* (Arun-dineae: Poaceae). *Contributions from the Bolus Herbarium* 12: 1–124.
- LOVEGROVE, B.G. & JARVIS, J.U.M. 1986. Co-evolution between mole-rats (Brathyrgeridae) and a geophyte, *Micranthus* (Iridaceae). *Cimbebasia* 8: 79–85.
- MANDERS, P.T. & CUNLIFFE, R.N. 1987. Fynbos plant life histories, population dynamics and species interactions in relation to fire: an overview. In R.M. Cowling *et al.*, *Disturbance and dynamics of Fynbos Biome communities*: 15–23. South African National Scientific Programmes Report No. 135.
- MOLL, E.J., CAMPBELL, B.M., COWLING, R.M., BOSSI, L., JARMAN, M.L. & BOUCHER, C. 1984. *A description of major vegetation categories in and adjacent to the Fynbos Biome*. South African National Scientific Programmes Report No. 83.
- RENVOIZE, S. 1981. The subfamily Arundinoideae and its position in relation to a general classification of the Gramineae. *Kew Bulletin* 36: 85–102.
- ROSHEVITS, R.Y. 1937. *Grasses. An introduction to the study of fodder and cereal grasses*. Indian National Scientific Documentation Center, New Delhi. Translated in 1980.
- RUTHERFORD, M.C. & WESTFALL, R. 1986. Biomes in southern Africa—an objective categorization. *Memoirs of the Botanical Survey of South Africa* No. 54: 1–98.
- STAPP, O. 1899. *Gramineae. Flora capensis*, vol. 7, ed. by W.T. Thiselton-Dyer. Lovell Reeve, London.
- TAKHTAJAN, A. 1986. *Floristic regions of the world*. University of California Press, Berkeley.
- TAYLOR, H.C., 1978. *Capensis*. In M.J.A. Werger, *Biogeography and ecology of southern Africa*. Junk, The Hague.
- TSVELEV, N.N. 1976. *Grasses of the Soviet Union*. Leningrad. English translation published by the Smithsonian Institution Libraries.
- VAN WILGEN, B.W. 1987. Fire regimes in the Fynbos Biome. In R.M. Cowling *et al.*, *Disturbance and dynamics of Fynbos Biome communities*: 6–14. South African National Scientific Programmes Report No. 135.
- WATSON, L. & DALLWITZ, M.J. 1988. *Grass genera of the world. Illustrations of characters, descriptions, classification, interactive identification, information retrieval*. Australian National University, Canberra.

The ecology of the False Bay estuarine environments, Cape, South Africa. 1. The coastal vegetation

M. O'CALLAGHAN*

Keywords: estuaries, False Bay, vegetation

ABSTRACT

The vegetation in and around eleven estuaries flowing into False Bay was surveyed during 1980 and 1981. Use was made of colour aerial photographs and a combination of dominance and phytosociological techniques. Of the communities established, three are aquatic and four are described as emergent or wetlands. Of the terrestrial communities, five are described as fynbos and four occur on coastal sands. One community consists solely of alien plants. The communities thus classified generally compare well with those discussed by other workers in the area. However, differences due to the destruction and disturbance of the vegetation are commented upon.

UITTREKSEL

'n Opname van die plantegroei in en rondom elf riviermondings wat in Valsbaai invloei, is gedurende 1980 en 1981 gemaak. Kleurfotos en 'n kombinasie van dominansie- en fitososiologiese tegnieke is gebruik. Van die gemeenskappe waarvan die teenwoordigheid vasgestel is, is drie akwaties en vier word as vleilande beskryf. Van die landgemeenskappe, word vyf as fynbos beskryf en vier kom op kussand voor. Een gemeenskap bestaan slegs uit uitheemse plante. Die gemeenskappe aldus geklassifiseer, vergelyk goed met dié wat deur ander werkers in die gebied bespreek word. Verskille wat egter aan die vernietiging en versteuring van die plantegroei toegeskryf kan word, word bespreek.

INTRODUCTION

An urban landscape (village, town, city) can be seen as a functional system requiring major inputs and outputs (energy, commodities, waste) to remain viable (Bartowski 1982). Rivers which traverse this system often provide convenient intra- and inter-system transport routes for these inputs and outputs. Rivers and other wetland areas are therefore in great demand and often over-utilized in urban environments. The loss of natural functioning of wetlands is an indication of the conservation mindedness of, or quality of planning by, the developers. Degradation of urban wetlands is usually due to: 1, alteration of hydrological régime; 2, reduction of the quality of water; 3, physical destruction of the system or parts thereof (Day 1987).

A river typically flows through a number of different environmental zones. Within each zone, local factors (for example flow rate, water depth, substrate) can vary considerably, resulting in a variety of wetland types along the river (seeps, bogs, emergent wetlands, submerged wetlands, swamps, vleis)(O'Keefe 1986).

It is generally accepted (see for example Goodman 1987) that wetlands function to improve the quality of the riverine environment (sediment trapping, flood attenuation, nutrient sink, production of food). The variety of wetland ecosystems found along a river should ensure that the riverine and related environments at the end of its course have a high quality. This can be seen by the high productivity estimates for estuaries in numerous texts (e.g. Whittaker 1970). However, even though wetlands are resilient in response to natural disturbance, they are susceptible to human influence. Furthermore, the

man-induced effects on the functioning of a riverine ecosystem are cumulative as one proceeds down the river course. Any deterioration of the riverine ecosystem will be reflected in the quality of the estuarine environment. This is shown in the present study by analysing the vegetation in and around the estuaries of False Bay.

STUDY AREA

False Bay (Cape, South Africa) is a large square-shaped bay with open access to the sea (Figure 1). The eastern and western sides of the Bay are bound by the Hottentots Holland and Cape Peninsula mountain ranges respectively

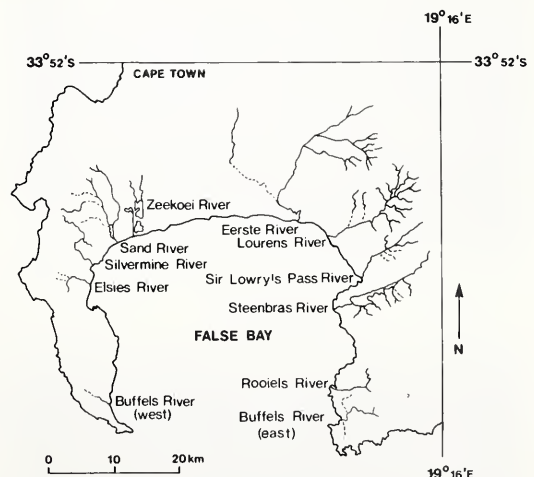


FIGURE 1.—The location of the rivers entering False Bay.

* National Botanical Institute, P.O. Box 471, Stellenbosch 7600.
MS. received: 1989.02.01.

and the northern shore is formed by the low sandy Cape Flats. The coastline, from Cape Point to Cape Hangklip, is approximately 121,5 km long.

The natural vegetation consists of mountain fynbos communities on sandstone-derived soils, particularly on the western and eastern sides of the Bay. The Cape Flats consist predominantly of calcareous sand supporting strandveld vegetation (Taylor 1980).

Many factors affect the Bay, some of which were discussed at a seminar entitled 'The future management of False Bay' (Gasson 1980). Pressures are being placed on the False Bay environment in the form of utilization by an ever-increasing local population for recreation, residence and industry; and by encroaching alien plants, especially Australian acacias. As such, there is need for well-planned management policies. However, available data are not sufficient for a complete understanding of the diversity and functioning of the False Bay environment. The formulation of well-planned management policies for this Bay is limited by the absence of adequate environmental data (Gasson 1980).

According to the 1:50 000 Topographical Sheets (3418AB & AD; 3418BA; 3418BB; 3418BD), eleven named rivers flow into False Bay. They are, from west to east (Figure 1): Buffels (West) (34°19'S; 18°28'E); Elsies (34°10'S; 18°26'E); Silvermine (34°07'S; 18°27'E); Sand (34°05'S; 18°28'E); Zeekoe (34°06'S; 18°30'E); Eerste (34°05'S; 18°46'E); Lourens (34°06'S; 18°49'E); Sir Lowry's Pass (34°09'S; 18°52'E); Steenbras (34°12'S; 18°49'E); Rooiels (34°18'S; 18°49'E); Buffels (East) (34°20'S; 18°50'E).

Much information concerning the biotic and abiotic features of these rivers has been published by Bickerton (1982), Cliff & Grindley (1982), Grindley (1982), Heineken (1982a,b), Heineken *et al.* (1982), Morant & Grindley (1982). The catchment area of these rivers exceeds 1100 km² and the mean annual run off is estimated as 200×10^6 m³/y. Residential and industrial effluent from at least six sewage works and an unknown number of storm water systems discharge into False Bay via these rivers. The rivers contain a number of dams, especially in the Hottentots Holland Mountain area, and water is extracted directly from some of the rivers for irrigation. They also receive runoff from farms, containing fertilizers, pesticides and other farm wastes. The Kuils River summer flow consists almost entirely of treated sewage effluent. Although the vegetation of False Bay has been discussed (Taylor 1980), no mention has been made of the vegetation in and around the estuaries.

METHODS

Physiographic/physiognomic units were demarcated on colour aerial photographs of 1979 (University of Natal Job 326/79) for each of the 11 river mouths. In total, approximately 83,6 ha was studied. The area studied at each river mouth varied from 3,1 ha (Elsies) to 25,8 ha (Sand). Each study site was selected to include aquatic, littoral and terrestrial vegetation.

The vegetation was sampled during 1980 and 1981. Relevés were not used. Each physiographic/physiognomic unit was regarded as a sampling unit. The sampling units were therefore not artificially bound, but each consisted of an entire physiographic/physiognomic unit. Where necessary, physiographic/physiognomic units were combined or further divided to obtain some degree of uniformity in the vegetation of each sampling unit.

The dominant and prominent species were recorded for each unit, together with a Braun-Blanquet cover-abundance value (see Braun-Blanquet 1965) for each recorded species. These floristic data were sorted by tabulation into communities using the TABSORT suite of computer programs (Boucher 1977).

RESULTS

Sampling units and vegetation types

A total of 301 species was recorded from 81 sampling units. Of these, 60% had a single occurrence in the data set. Undersampled vegetation types were not resampled. Of those species that occurred more than once, one could not be identified to the species level. In total, 44 specimens could not be identified to the species level.

Fourteen of the sampling units contained only one species. These monospecific communities were confined to submerged aquatics, emergent reeds and alien shrubs.

Table 1 is a summary of the vegetation types found. The name of each vegetation type was selected for the sake of convenience only, usually according to the two dominant species. A complete list of species and sorted phytosociological tables are available on request.

The average numbers of species recorded for each vegetation type were: Submerged Aquatic Communities, 1,0; Emergent and Wetland Communities, 5,2; *Cassine barbara* Communities, 20,2; Non-littoral Dune Communities, 14,8; Littoral Dune Communities, 6,5.

Vegetation maps of each river mouth were prepared, but have been published elsewhere (Bickerton 1982; Cliff & Grindley 1982; Grindley 1982; Heineken 1982a,b; Heineken *et al.* 1982; Morant & Grindley 1982).

DESCRIPTION OF COMMUNITIES

(Note that alien plants are not mentioned in the description of the communities. They are discussed separately under 3.3)

1 Submerged Aquatic Communities

Three aquatic species were recorded in the study area: *Potamogeton pectinatus*, *Ruppia cirrhosa* and *R. maritima*. Each of these species forms monospecific stands and these should be regarded as distinct communities. *Potamogeton pectinatus* forms tall dense subsurface stands in fresh to slightly brackish waters. *Ruppia* spp. are found in shallower water: *R. maritima* forms sparse communities

TABLE 1.—Names of communities and the rivers at which they occur

Community	Rivers
1 Submerged Aquatic Communities	4 10 11
1.1 <i>Potamogeton pectinatus</i> Submerged Community	4
1.2 <i>Ruppia cirrhosa</i> Submerged Community	10
1.3 <i>Ruppia maritima</i> Submerged Community	4 11
2 Emergent and Wetland Communities	1 2 3 4 5 6 7 8 10 11
2.1 <i>Phragmites australis</i> Emergent Community	3 4 6 7 10 11
2.2 <i>Paspalum vaginatum</i> Wetland Community	2 3 6 7
2.3 <i>Scirpus maritimus</i> Mixed Community	4 6 8
2.4 <i>Typha capensis</i> Emergent Community	1 2 5 7
3 Terrestrial Communities	1 2 3 4 5 6 7 8 9 10 11
3.1 <i>Cassine barbara</i> Fynbos Communities	9 10
3.1.1 <i>C. barbara</i> – <i>Leucodendron salignum</i> Dry Mountain Community	9 10
3.1.1.1 <i>L. salignum</i> – <i>Thamnochortus gracilis</i> Mountain Community	9
3.1.2 <i>C. barbara</i> – <i>Polygala myrtiflora</i> Coastal Community	10
3.1.3 <i>C. barbara</i> – <i>Rhus lucida</i> Riparian Community	9 10
3.1.3.1 <i>R. lucida</i> – <i>Pelargonium angulosum</i> Riparian Community	9 10
3.2 <i>Tetragonia decumbens</i> Coastal Sand Communities	1 2 3 4 5 6 7 8 10 11
3.2.1 <i>T. decumbens</i> – <i>Sideroxylon inerme</i> Mature Hind-dune Community	3 6 11
3.2.2 <i>T. decumbens</i> – <i>Senecio halimifolius</i> Moist Dune Community	4 5 6 11
3.2.3 <i>T. decumbens</i> – <i>Metalasia muricata</i> Mid-dune Community	1 2 3 4 5 6 7 10 11
3.2.4 <i>T. decumbens</i> – <i>Agropyron distichum</i> Fore-dune Community	3 5 6 7 8 10 11
3.3 <i>Acacia cyclops</i> Monospecific Community	1 2

Rivers: 1 = Buffels (west); 2 = Elsies; 3 = Silvermine; 4 = Sand; 5 = Zeekoe; 6 = Eerste; 7 = Lourens; 8 = Sir Lowry's Pass; 9 = Steenbras; 10 = Rooiels; 11 = Buffels (east).

in areas of weak salinity; *R. cirrhosa* requires higher salinities and can form relatively dense stands. Within this study area, aquatic plants were found only at Sand, Rooiels and Buffels (East). These systems are either very large (Sand) or relatively undisturbed. If the study areas were increased to extend along the rivers, it is likely that submerged aquatics would also be found in some of the other systems.

It should be noted that the aquatic environments are dynamic and imposed management procedures which affect these communities are ongoing in these estuaries (Bickerton 1982; Cliff & Grindley 1982; Grindley 1982; Heineken 1982a,b; Heineken *et al.* 1982; Morant & Grindley 1982).

1.1 *Potamogeton pectinatus* Submerged Community: this community was found only at Sand where it is confined mainly to the middle reaches of the vle. It thrives in this brackish to fresh, nutrient-rich water to form dense meadows that are 'managed' by weed cutting (Morant & Grindley 1982).

1.2 *Ruppia cirrhosa* Submerged Community: this species is restricted to the shallow areas above the road bridge at the Rooiels River.

1.3 *Ruppia maritima* Submerged Community: these communities are found at the Sand and the Buffels (East) Rivers, to a depth of 800 mm in clear water.

2 Emergent and Wetland Communities

The only truly tidal estuary along the False Bay coast is found at the Steenbras River. The other estuaries have strong fluvial input during winter and the mouths usually close during summer. However, the banks of the Steenbras River are covered by boulders, and wetland vegetation does

not occur. All the other estuaries have wetland communities which, to some extent, reflect the prevailing water régimes. All the wetlands are poorly developed and most show signs of disturbance. They generally contain only one or a few species and do not display zonation patterns. Two of the communities have a tall emergent growth form and two may be flooded seasonally or tidally.

2.1 *Phragmites australis* Emergent Community: *Phragmites australis* usually forms monospecific stands, up to 2,5 m tall, on substrates where silt deposition occurs. This species grows optimally in water with a salinity of less than 15 ‰, although it can withstand higher salinities (Benfield 1984).

In the estuaries studied, *Phragmites* forms a fairly dense stand at the Rooiels River with other wetland species such as *Chenolea diffusa*, *Juncus acutis*, *Sarcocornia* spp., *Scirpus nodosus*, *Sporobolus virginicus* and *Stenotaphrum secundatum*. At the Silvermine, Sand, Eerste and Buffels (East) estuaries, *Phragmites* forms very dense monospecific stands. These emergent communities generally grow in areas away from the river mouth where there is little or no salt water penetration. They are emergent in varying water depths, especially during the rainy season, or may be exposed to some tidal fluctuation if the mouth is open.

2.2 *Paspalum vaginatum* Wetland Community: this community is found on coarse saline sands and withstands lengthy periods of inundation. It forms monospecific stands at the Elsies Estuary. At the Eerste River estuary, *Cotula coronopifolia* and *Scirpus nodosus* are found in this vegetation type, whereas at the Lourens Estuary, two communities are present, one being monospecific and the other containing various *Cliffortia* and *Cyperus* species. *Paspalum vaginatum* is regarded by some as an alien grass

(Bond & Goldblatt 1984). In some areas, this community also contains numerous alien herbs and shrubs.

2.3 *Scirpus maritimus* Mixed Community: these plants are generally found on non-saline sandy soils that contain some organic matter. Many of them survive inundation in an emergent form. At the Sand River, this community includes other Cyperaceae, *Sarcocornia natalensis*, *Paspalum vaginatum*, *Typha capensis* and *Triglochin bulbosa*. At the Sir Lowry's Pass River, *Cliffortia lanceolata*, *Triglochin bulbosa* and *Juncus rigidus* are included. At the Lourens River estuary, *Scirpus maritimus* forms a monospecific stand.

2.4 *Typha capensis* Emergent Community: this community is emergent in slow-running, fresh water. The species forms monospecific stands at the Elsies and Lourens estuaries, the latter being a wetland not in direct contact with riverine flow. At the Buffels (West) and Zeekoe Rivers, numerous other species such as *Samolus valerandii*, *Berula thunbergii*, *Triglochin striata*, *Senecio halimifolius*, *Scirpus nodosus*, *Zantedeschia aethiopica* and *Polygonum salicifolium* also occur.

3 Terrestrial Communities

The terrestrial vegetation comprises two basic types. The first is distinguished by the presence of *Cassine barbara* and is found on soils derived from Table Mountain Sandstone. It occurs in the mountainous areas along the eastern and western shores of the Bay. The second type of terrestrial vegetation contains *Tetragonia decumbens*. This vegetation grows on recent calcareous sands along the northern shore of the Bay and in the river valleys where this soil type has accumulated.

3.1 *Cassine barbara* Fynbos Communities: within this study area, fynbos occurs only at the Steenbras River mouth and Rooiels River mouth, predominantly on shallow sandstone soils. Boucher (1978) records *C. barbara* on littoral dunes, on limestone and in riverine scrub in the Cape Hangklip area. It would seem that this species is tolerant of a wide range of habitat factors and its value as a diagnostic species is, therefore, suspect. Nevertheless, Taylor (1969) found this species in a subassociation of upland fynbos. Other species common to this community (*Leucospermum conocarpodendron*, *Widdringtonia nodiflora*) help to distinguish this fynbos community.

3.1.1 *C. barbara*–*Leucadendron salignum* Dry Mountain Community: this community is indicative of Dry Mountain Fynbos in this area (see Boucher's (1978) community 3.2.2.1). The *L. salignum*–*Thamnochortus gracilis* variation (3.1.1.1) was found at the Steenbras River and seems to be a form characteristic of slightly moister conditions.

3.1.2 *C. barbara*–*Polygala myrtiflora* Coastal Community: this vegetation was found at the Rooiels River and does not compare well with any of Boucher's (1978) communities. It contains *Protea compacta*, *Phyllica ericoides*, *Chondropetalum microcarpum* and *Myrica quercifolia*. A better sampling technique might indicate a combination of Boucher's (1978) Acid Sand Fynbos and

South Coast Strandveld. However, C. Boucher (pers. comm.) suggests that, in this region, *P. compacta* does not occur naturally west of the Palmiet River Mouth and this community might be a dune/limestone community (see 3.1).

3.1.3 *C. barbara*–*Rhus lucida* Riparian Community: this is found in the narrow valleys of the Steenbras and Rooiels Rivers with *Psoralea pinnata*, *Podalyria calypttrata* and others. The *R. lucida*–*Pelargonium angulosum* variation (3.1.3.1) is usually found at the coastal or riverine edge of the community.

3.2 *Tetragonia decumbens* Coastal Sand Communities: these communities were found at all the rivers in this study area.

3.2.1 *T. decumbens*–*Sideroxylon inerme* Mature Hind-dune Community: this community was found at the Silvermine, Eerste and Buffels (East) Rivers (although it was also noted outside the boundary of the study area at the Buffels (West) River) and compares well with Boucher (1978), Taylor (1969) and Taylor (1980). The structure of this community is highly variable. In protected areas, it forms a low forest (up to 5m) with a closed canopy of *S. inerme*, generally with an open understorey of grasses, herbs and shrubs such as *Cussonia thyrsiflora* and *Chasmanthe aethiopica*. In more exposed areas, this community is usually wind-cropped to form a dense shrubland from 0,5 m to 2 m.

T. decumbens is seldom found in this community and *Ehrharta villosa* might have been a better diagnostic species for these (3.2) communities.

3.2.2 *T. decumbens*–*Senecio halimifolius* Moist Dune Community: this community compares well with Taylor (1980) and was found at the Sand, Zeekoe, Eerste and Buffels (East) Rivers, mainly in dune slacks and poorly drained dune areas. It varies in height from 0,8 m to 1,5 m and can contain other species such as *Scirpus nodosus*, *Zantedeschia aethiopica*, *Typha capensis*, *Nidorella foetida*, *Juncus kraussii*, as well as shrubs and herbs more typical of dune vegetation in this area.

3.2.3 *T. decumbens*–*Metalasia muricata* Dune Community: this community is typical of deep coastal sands where the above conditions do not prevail. Its structure varies from a relatively sparse low-growing shrubland up to 2 m. It was found on the non-littoral dunes near all the rivers except at the Steenbras where dunes do not occur. It can be subdivided into various classes and associations (see below).

3.2.4 *T. decumbens*–*Agropyron distichum* Fore-dune Community: this community consists of psammophilous pioneer vegetation which is commonly found on the fore-dunes. It is dominated by a sparse or open cover of grasses and herbs. It compares well with Boucher's (1978) 'Ehrharta–*Ficinia* Strand Pioneers' and Taylor's (1969) 'Pioneer Mixed Dune Fynbos' to which Taylor gives the status of subassociation.

3.3 *Acacia cyclops* Monospecific Community: alien shrubs and grasses were found throughout most of the emergent,

wetland and terrestrial vegetation units. *Acacia cyclops* is particularly common in the vegetation on coastal sands whereas *Pennisetum clandestinum* is found in these as well as wetland communities. Alien plants recorded (according to Bond & Goldblatt 1984) include *Acacia cyclops*, *A. longifolia*, *A. mearnsii*, *A. saligna*, *Paraserianthes lophantha* subsp. *lophantha*, *Ammophila arenaria*, *Aster subulatus*, *Atriplex vestita*, *Avena sativa*, *Briza maxima*, *Bromus diandrus*, *Chenopodium ambrosioides*, *C. murale*, *Datura stramonium*, *Eucalyptus globulus*, *E. lehmannii*, *Lagurus ovatus*, *Malva parviflora*, *Myoporum serratum*, *Paspalum vaginatum*, *P. urvillei*, *Pennisetum clandestinum*, *Populus canescens*, *Pinus pinaster*, *P. pinea*, *Pinus* sp., *Solanum nigrum*, *Sonchus asper*, *S. oleraceus*, *Trapaeolum majus*, and *Urtica urens*.

Where present, these species dominate the vegetation to varying degrees; usually causing a loss in species richness and cover of the natural vegetation. At the Buffels (West) and Elsies Rivers, *A. cyclops* has, in places, ousted the natural vegetation to form monospecific stands.

COMPARISON OF COMMUNITIES WITH THOSE OF BOUCHER (1987)

Boucher (1987) carried out a survey of the western Cape coastal forelands. Included in his study area was a part of the False Bay coast, approximately from the Zeekoe to Eerste Rivers. The communities he found within 1 km of this coast are listed in Table 2.

From the above table, classes 5.1 and 5.2 are equivalent to coastal sand communities. Class 5.4 indicates halophytic marshes; class 5.6 indicates non-riverine (inter-dune) wetlands; class 5.7 is found along water courses.

When comparing the present study with that of Boucher's (1987) study, the following points are evident: according to Boucher (1987), the association 5.1.1.2 C is found on the dunes along this coast. This should therefore be equivalent to the above *T. decumbens*-*Agropyron distichum* Community. However, sampling procedures used for the present study do not allow for classification to the level of association. Also, other species in this community seem to indicate a combination of Boucher's *Cladoraphio-Hebenstreton cordatae* (5.1.1.2) alliance and an association designated *Senecioni-Ammophiletum arenariae* (5.1.1.1.A), belonging to the alliance *Cladoraphio-Senecion elegantis* (5.1.1.1). Boucher regards this last association as artificial owing to the dominance of the alien grass *Ammophila arenaria*.

The strong presence of *Metalasia muricata* in the *T. decumbens*-*Metalasia muricata* Community would, according to Boucher (1987), place this community in the association *Senecioni-Metalasietum muricatae* (5.1.1.1.B). This association again falls into the alliance *Cladoraphio-Senecion elegantis* (5.1.1.1) which he did not record within 100 m of the False Bay coast.

The remainder of the terrestrial dune communities along this coast were classified by Boucher (1987) as belonging to the class *Ehrhartetea calycinae* (5.2). In the present study, *Ehrharta villosa* was recorded as being co-dominant with *Tetragonia decumbens* in the dune communities. It

TABLE 2.—List of communities within 1 km of the False Bay Coast (after Boucher 1987)

Rank	Name	Text reference
Class	<i>Arctothecetea populifoliae</i>	5.1
Order	<i>Arctotheco-Cladoraphietalia cyperoidis</i>	5.1.1
Alliance	<i>Cladoraphio-Hebenstreton cordatae</i>	5.1.1.2
Association	<i>Hebenstreton-Chenoleetum diffusae</i>	A
Class	<i>Ehrhartetea calycinae</i>	5.2
Order	<i>Ehrharto-Eucleetalia racemosae</i>	5.2.1
Alliance	<i>Eucleo-Ischyrolepion eleocharidis</i>	5.2.1.4
Association	<i>Ischyrolepo-Oleetum exasperatae</i>	A
	<i>Ischyrolepo-Kedrostietum nanae</i>	B
	<i>Ischyrolepo-Ifloetum ambiguae</i>	E
Subassociation	<i>typicum</i>	a
	<i>koelerietosum</i>	b
	<i>thamnochortetosum</i>	c
	<i>romuleetosum</i>	d
Association	<i>Ischyrolepo-Myricetum cordifoliae</i>	F
Subassociation	<i>typicum</i>	a
	<i>senecietosum</i>	b
Association	<i>Ischyrolepo-Cullumietum squarrosae</i>	G
	<i>Ischyrolepo-Crassuletum subulatae</i>	H
Subassociation	<i>typicum</i>	a
	<i>pharnacetosum</i>	b
Association	<i>Eucleo-Ischyrolepetum</i>	J
Order	<i>Ehrharto-Ericetalia coerctatae</i>	5.2.4
Alliance	<i>Erico-Aspalathion</i>	5.2.4.1
Association	<i>Aspalatho-Phyllicetum ericoides</i>	A
	<i>Aspalatho-Struthioletum salteri</i>	B
Class	<i>Sarcocornietea pillansiae</i>	5.4
Order	<i>Sarcocornio-Juncetalia kraussii</i>	5.4.2
Association	<i>Junco-Chondropetalum tectorum</i>	B
	<i>Junco-Phragmitetum australis</i>	C
Order	<i>Sarcocornio-Galenietalia africanae</i>	5.4.3
Association	<i>Sarcocornio-Galenietum</i>	A
Class	<i>Scirpetea nodosi</i>	5.6
Association	<i>Scirpo-Linetum africanae</i>	A
	<i>Scirpo-Nidorelletum foetidi</i>	B
Class	<i>Polygonetea salicifoliae</i>	5.7
Association	<i>Polygono-Juncetum capensis</i>	A
	<i>Polygono-Stoebeum vulgaris</i>	B
	<i>Polygono-Pycnetum polystachyi</i>	C
	<i>Polygono-Cliffortietum odoratae</i>	D

is possible that *E. villosa* was confused with *E. calycina* in some areas. Neither *Sideroxylon inerme* nor *Cussonia thyrsiflora* were recorded by Boucher (1987). The above community described as *T. decumbens*-*Sideroxylon inerme* Community therefore has no counterpart in his system. Boucher *et al.* (1986) suggest that the class *Arctothecetea populifoliae* be divided into two orders: *Arctotheco-Cladoraphietalia cyperoidis* and *Arctotheco-Passerinetalia rigidae*. According to these latter authors, the geographical separation occurs at Cape Point, with the former order to the west. However, Boucher (1987) includes vegetation sampled along the False Bay coast in the former order. The differential species for these orders were not common in the present study. Considering the preponderance of *Sideroxylon inerme* and *Cussonia thyrsiflora* on the dunes of the southern and eastern Cape (pers. obs.), if this community belongs to the class 5.1, it is likely to be found in the order *Arctotheco-Passerinetalia rigidae* (Boucher *et al.* 1986), even though it was

found on the western shores of the Bay. However, if *Ehrharta calycina* was misidentified (as *E. villosa*), this community might fall into the class *Ehrharteetea calycinae* (5.2).

The community found on moist dune slacks (*T. decumbens*–*Senecio halimifolius* Community) would belong to Boucher's (1987) class 5.6 *Scirpetea nodosi*. This class consists of two associations: *Scirpo-Linetum africanum* and *Scirpo-Nidorelletum foetidi*. The major part of the community described in this study falls within the latter association; according to Boucher, it is found near Swartklip (in the vicinity of the Eerste River). The former association seems to be poorly represented in the present study and, contrary to Boucher's (1987) findings, was found at the Buffels (East) River and not at the rivers near Mitchell's Plain.

The wetland vegetation Boucher (1987) recorded along this coast belongs to the classes *Sarcocornietea pillansiae* (5.4) and *Polygonetea salicifoliae* (5.7). The former describes halophytic salt marshes and the latter describes the vegetation fringing water courses.

The estuaries along the False Bay coast are relatively small and do not have a regular tidal fluctuation nor saline input. Halophytic wetlands are therefore poorly developed. Nevertheless, these vegetation types did occur historically (O'Callaghan 1990) and some of the species of these communities are present. Boucher's (1987) differential species *Sarcocornia pillansii* was found only at Sandvlei whereas one of his dominants, *Sporobolus virginicus*, has a wider distribution.

The emergent community described above as the *Phragmites australis* Community is recognized by Boucher (1987) as the association *Junco-Phragmitetum australis* (5.4.2.C) in the order *Sarcocornio-Juncetalia kraussii*. The *Paspalum vaginatum* Wetland Community indicates Boucher's association 5.4.2.B: *Junco-Chondropetaletum tectorum*.

The *Scirpus maritimus* Mixed Community does not have a counterpart in Boucher's system. He recorded this species only once and another species in this community (*Triglochin bulbosa*) is noted as being differential and widespread for his class 5.4.

The *Typha capensis* Emergent Community indicates the association *Junco-Nidorelletum foetidi* (5.4.2.A) in the order *Sarcocornio-Juncetalia kraussii*. However, the presence of *Polygonum salicifolium* indicates the class *Polygonetea salicifoliae*, in particular, the association *Polygono-Juncetum capensis* (5.7.A). *Typha capensis* was recorded in the present study from the inter-dune wetlands, adjacent to permanent water and alongside streams. It is therefore likely that this community represents a mixture of associations found in the classes *Sarcocornietea pillansiae* (5.4), *Scirpetea nodosi* (5.6) as well as *Polygonetum salicifoliae* (5.7), but mainly 5.6 and 5.7.

CONCLUSIONS

The studies by Boucher (1978, 1987) and Taylor (1969, 1980) were carried out in relatively pristine vegetation and

over far larger areas than the present study. The communities they established are, therefore, a better indication of the natural vegetation of the area. Although the vegetation units established by the current study are generally similar to their communities, there are problems in matching, particularly with the dune and wetland vegetation types. These difficulties may be due to differences in sampling techniques, but they could also be due to disturbance and destruction of the natural vegetation in the present study area.

O'Callaghan (1990) has shown that much vegetation around these estuaries has been destroyed by residential, recreational and industrial developments. In addition, alien plants and trampling have brought about a loss of species richness and natural plant cover.

The wetland vegetation types are particularly difficult to match with those discussed by Boucher (1987). Although the above influences affect these vegetation types, additional influences such as the quality of water in the rivers and the disturbance of natural flow régimes also play a role. It seems that, where they exist, the wetlands around the rivers entering False Bay are in a poor condition.

Gasson & MacKinnon (1983) have estimated the volume of outfall entering the False Bay catchment. The domestic outfall is expected to increase from 146,525 Ml/d to 261,5 Ml/d, i.e. by 78,5% between 1982 and 1990. The volume of outfall for industrial waste was 7,34 Ml/d in 1982 and it is not unreasonable to assume that these volumes will also increase dramatically. By 1990, more than 500 Ml/d of polluted water might be flowing into False Bay, approximately 60% via the rivers.

Gasson & MacKinnon (1983) state that the standard of effluent disposal is generally above the acceptable norms set by the authorities. However, some treatment works may, at times, release effluent which is below standard (e.g. Kuils River). Furthermore, the record and control of effluent entering the rivers via routes other than through municipal treatment works is scarce.

Whether this effluent enters directly or indirectly by surface run off, it affects the vegetation around the rivers: species richness is reduced and dominance by a single species increased, which results in an increase of structural homogeneity of the wetlands around these estuaries. This, together with the physical destruction of the wetland environments for development will cumulatively affect the ecology of the estuaries and the quality of water entering the Bay. It seems that a well-planned interdepartmental management scheme (see Malan 1982) for False Bay, including catchment areas, is indicated.

REFERENCES

- BARTOWSKI, T. 1982. Towns eco-geosystem versus rural geocomplex; case study of the Poznan agglomeration. In S.P. Tjallingii & A.A. de Veers, *Perspectives in landscape ecology*: 74–77. Centre for Agricultural Publication and Documentation, Wageningen.
- BENFIELD, M.C. 1984. *Some factors influencing the growth of Phragmites australis (Cav.) Trin. ex Steudel*. M.Sc. thesis, University of Natal.

- BICKERTON, I.B. 1982. Report No. 15: Zeekoe (CSW 5). In A.E.F. Heydorn & J.R. Grindley, *Estuaries of the Cape, part II: synopses of available information on individual systems*. CSIR Research Report No. 414.
- BOND, P. & GOLDBLATT, P. 1984. Plants of the Cape flora—a descriptive catalogue. *Journal of South African Botany* Supplement 13.
- BOUCHER, C. 1977. Cape Hangklip area. I. The application of association-analysis, homogeneity functions and Braun-Blanquet techniques in the description of south-western Cape vegetation. *Bothalia* 12: 293–300.
- BOUCHER, C. 1978. Cape Hangklip area. II. The vegetation. *Bothalia* 12: 455–497.
- BOUCHER, C. 1987. *A phytosociological study of transects through the western Cape coastal foreland, South Africa*. Ph.D. dissertation, University of Stellenbosch.
- BOUCHER, C., LE ROUX, A. & TAYLOR, H.C. 1986 (abstract). *Strand vegetation of the Cape between the Orange and Sundays River Mouth*. Symposium on the structure and functioning of sand dune ecosystems, Port Elizabeth.
- BRAUN-BLANQUET, J. 1965. *Plant sociology: the study of plant communities*. (Translated, revised & edited by C. D. Fuller & H. S. Conrad). Hafner, London.
- CLIFF, S. & GRINDLEY, J.R. 1982. Report No. 17: Lourens (CSW 7). In A.E.F. Heydorn & J.R. Grindley, *Estuaries of the Cape, part II: synopses of available information on individual systems*. CSIR Research Report No. 416.
- DAY, J.A. 1987. Conservation and management of wetlands in the greater Cape Town area. In R.D. Walmsley & M.L. Botten, *Ecology and conservation of wetlands in South Africa*: 185–194. CSIR Occasional Report No. 28.
- GASSON, B. ed. 1980. *Proceedings of symposium on the future management of False Bay*. Cape Town.
- GASSON, B. & MACKINNON, R. 1983. *False Bay catchment: sewage forecast*. CSIR Research Report C/SEA 8245.
- GOODMAN, P.S. 1987. Natal Parks Board. In R.D. Walmsley, & M.L. Botten, *Ecology and conservation of wetlands in South Africa*: 30–37. CSIR Occasional Report No. 28.
- GRINDLEY, J.R. 1982. Report No. 16: Eerste (CSW 6). In A.E.F. Heydorn & J.R. Grindley, *Estuaries of the Cape, part II: synopses of available information on individual systems*. CSIR Research Report No. 415.
- HEINECKEN, T.J.E. 1982a. Report No. 13: Silvermine (CSW 3). In A.E.F. Heydorn & J.R. Grindley, *Estuaries of the Cape, part II: synopses of available information on individual systems*. CSIR Research Report No. 412.
- HEINECKEN, T.J.E. 1982b. Report No. 8: Rooiels (CSW 10). In A.E.F. Heydorn & J.R. Grindley, *Estuaries of the Cape, part II: synopses of available information on individual systems*. CSIR Research Report No. 407.
- HEINECKEN, T.J.E., BICKERTON, I.B. & MORANT, P.D. 1982. Report No. 12: Buffels (wes) (CSW 1), Elsies (CSW 2), Sir Lowry's Pass (CSW 8), Steenbras (CSW 9) and Buffels (oos) (CSW 11). In A.E.F. Heydorn & J.R. Grindley, *Estuaries of the Cape, part II: synopses of available information on individual systems*. CSIR Research Report No. 411.
- MALAN, J. 1982. *The formulation of an administrative structure for the management of False Bay*. School of Environmental Studies Report No. 35, University of Cape Town.
- MORANT, P.D. & GRINDLEY, J.R. 1982. Report No. 14: Sand (CSW 4). In A.E.F. Heydorn & J.R. Grindley, *Estuaries of the Cape, part II: synopses of available information on individual systems*. CSIR Research Report No. 413.
- O'CALLAGHAN, M. 1990. The ecology of the False Bay estuarine environments, Cape, South Africa. 2. Changes during the last fifty years. *Bothalia* 20: 113–122.
- O'KEEFE, J.H. 1986. *Ecological research on South African Rivers—a preliminary synthesis*. South African Scientific Programmes Report No. 121.
- TAYLOR, H.C. 1969. *A vegetation survey of the Cape of Good Hope Nature Reserve*. M.Sc. thesis, University of Cape Town.
- TAYLOR, H.C. 1980. Plant communities along the False Bay coast. In B. Gasson, *Proceedings of symposium on the future management of False Bay*: 59–67.
- WHITTAKER, R.H. 1970. *Communities and ecosystems*. MacMillan, New York.

The ecology of the False Bay estuarine environments, Cape, South Africa. 2. Changes during the last fifty years

M. O'CALLAGHAN*

Keywords: estuaries, False Bay, management

ABSTRACT

Aerial photographs taken between 1936 and 1987 of the eleven rivers flowing into False Bay were studied. Various techniques were used to obtain quantitative values and value judgements for the changes that had taken place. It was found that large increases in industrial, residential, recreational areas and alien plant cover have taken place at the expense of open sand and natural vegetation types. The rivers along the eastern shore of the Bay are relatively undisturbed. Those along the western shore are more disturbed but still contain some noteworthy environments. The most detrimental changes have occurred around the rivers of the Cape Flats, along the northern shore.

UITTREKSEL

Lugfotografies vanaf 1936 tot 1987 van die elf riviere wat in Valsbaai uitmond, is bestudeer. Verskeie tegnieke is gebruik om kwantitatiewe waardes en waardebeslissings vir die veranderinge wat plaasgevind het, te verkry. Daar is bevind dat groot toenames in nywerheids-, woon-, ontspanningsgebiede en uitheemse plantegroei plaasgevind het ten koste van oop sand en natuurlike plantegroei-tipes. Die riviere aan die ooskus van die Baai is betreklik onversteur. Dié van die westekant is meer versteur, maar daar het tog enkele natuurlike omgewings langs die riviermondings behoue gebly. Die skadelikste veranderinge het langs die riviere van die Kaapse Vlakte aan die noordelike kuslyn plaasgevind.

CONTENTS

Introduction	113
Methods	114
Delineation of mapping units	114
Evaluation of changes	114
1 Relative environmental importance (I)	114
2 Relative environmental state (E)	116
3 Co-efficient of change (A)	116
4 Conservability (C)	116
Changes observed in different environments	116
Water and wetlands	117
Dune vegetation	117
Riverine scrub and fynbos	117
Factors causing changes	118
Alien vegetation	118
Residential development	118
Recreational development	118
Industrial development	118
Discussion of individual estuaries	118
Buffels (West)	118
Elsies	119
Silvermine	119
Sand	119
Zeekoe	119
Eerste	119
Lourens	119
Sir Lowry's Pass	120
Steenbras, Rooiels and Buffels (East)	120
Comparison of estuaries	120
Conclusions	120
References	121

INTRODUCTION

Patterns of development vary in different environments. A typical pattern in a terrestrial environment might range from uniform natural landscapes to a mosaic of natural and man-made landscapes. As the demand for land increases, the landscape is inexorably converted from a natural to a man-made landscape (Schroever 1982).

Gasson (1980), at a symposium discussing the management needs of False Bay, divided the area into five zones: the deep water area of the Bay itself; the near-shore zone; the intertidal zone; the back-shore zone; and the hinterland. Rivers are an important continuous connection from the hinterland, through the back-shore and intertidal areas, to the near-shore environment and, through dispersal, to the Bay itself. However, very little, if any, mention was made of the rivers flowing into False Bay at this symposium.

The quality of much of the water flowing into this bay has been reduced by developments in the hinterland, as shown by the deterioration of the estuarine environments (O'Callaghan 1990). However, the coastal environment is also under developmental threat, and has been for many decades. Calls have been made for an integrated management policy for the False Bay area (Malan 1982; Gasson 1980). Very little has, as yet, been achieved.

Along any coastline, the greatest diversity of habitats is usually to be found in and around estuaries. Not only are the coastal terrestrial environments present, but wetland habitats, saline habitats and combinations of these are also to be found. Unfortunately, estuarine areas are sensitive to man-induced disturbances and are often in great demand for various types of development. Being in

* National Botanical Institute, P.O. Box 471, Stellenbosch 7600.

TABLE 1. — Aerial photographs of estuaries used for this study. Scale \pm 1:10 000. Housed at Trigonometrical Survey, Mowbray, unless otherwise stated

	Buffels (W)	Elsies	Silver- mine	Sand	Zeekoe	Eerste	Lourens	Sir Lowry's Pass	Steen- bras	Rooiels	Buffels (E)
	Photo no.										
Job 61/44: B & W, 1944	374	189	193	103	—	—	—	—	—	—	—
Job 326/79: Col.; 1979; Dept. Land Surveying, Univ. Natal	375/3	372/3	369/3	367/3	363/3	362/3	359/3	358/3	356/3	354/3	352/3
Job 126/38: B & W, 1938	—	—	—	—	11723	11697	12611	12665	12696	12775	12807
Job 424/58: B & W, 1958	—	7009	7010	6997	6995	—	—	—	—	—	—
Job 335/53: B & W, 1953	—	—	—	—	—	6114	6113	—	—	—	—
Job 461/61: B & W, 1961	—	—	—	—	—	—	—	433	—	—	—
	Page; negative no.										
ECRU/EMA: Col.; 1987; CSIR, Stellenbosch	35; 1	37; 13	37; 10	38; 6	38; 10	39; 14	40; 4	40; 11	41; 13	42; 11	42; 15–16

close proximity to a major city, the False Bay estuaries are no exception. The aim of this study is to ascertain and quantify, as an aid to management, the changes that have occurred around the estuaries of False Bay, as described by O'Callaghan (1990).

METHODS

Delineation of mapping units

Aerial photographs, from 1938 to 1979 (see Table 1), of each of the estuaries were studied to delineate various mapping units. It was ensured that, if present, the mapping units would be distinguishable on all the aerial photographs. After they had been selected, the homogeneity and practicability of each unit was checked by field observation.

The following mapping units were thus defined: 1, water; 2, rock; 3, sand and pioneer vegetation; 4, dune scrub (Boucher 1987; Moll *et al.* 1984; Taylor 1980); 5, wetlands; 6, riverine scrub; 7, fynbos (Boucher 1978, 1987; Moll *et al.* 1984; Taylor 1969, 1980); 8, alien vegetation (Sturton 1978); 9, agricultural lands; 10, residential areas; 11, recreational areas; 12, industrial areas; 13, roads and rail.

Either two or three photographs, depending on the amount of change that had taken place over the years, were selected to form a temporal series for each estuary. A Bausch and Lomb Zoom Transfer Scope (Model 53-05-04-23) was used to draw the outlines of the mapping units for each estuary from colour aerial photographs of 1979, thus producing a land use map for 1979. A copy was made of this map and the preceding photograph of the temporal series was superimposed thereon. The land use map was adapted by redrawing the mapping units so as to correspond with the preceding photograph. This process was repeated until land use maps had been drawn for all the estuaries and all the aerial photographs of a temporal series.

An area extending approximately 250 m on either side of the river mouth and 1 km inland from the shore was

selected. The area of each mapping unit within this selected area was measured and corrected according to methods set out in O'Callaghan (1985).

The results of this procedure are shown in Table 2. From this table one can observe the changes in land use that have taken place at each estuary. These changes can be measured and compared. They can be related to developmental patterns in different parts of the environment. However, integrated measurements and environmental values are often required to compare different areas and to facilitate decision making.

Evaluation of changes

Numerous techniques exist whereby some measure of relative environmental importance can be determined (Linston 1975). These usually require much expertise, time and money; commodities which are not always readily available to those who make decisions about the environment. For this study, these methods were simplified, making use of some of the principles of more complex techniques.

The procedures used can be divided into four stages: 1, the determination of the relative environmental importance (I) of each mapping unit; 2, the determination of relative environmental states (E) for each estuary; 3, the determination of a co-efficient of change (A) which is a measure of how much the environmental state of each estuary has changed over the years; 4, the determination of a conservability co-efficient (C) which integrates the above.

1 Relative environmental importance (I)

The assigning of values to parts of the environment is a subjective process. Values can vary according to characteristics of the evaluators (Sandbach 1980). Numerous techniques have been developed to overcome this subjectivity (Fuggle 1983) and the use of specialist panels (Helmer 1963) is widely accepted. As these procedures are costly, a compromise is made by using a small panel and critically analysing the results.

TABLE 2. —Changes in area (ha) of each mapping unit from each aerial photograph of a temporal series

River	Year	Water	Rocks	Sand & pioneers	Dune scrub	Wet-lands	River scrub	Fynbos	Alien veget.	Farm areas	Resid. areas	Recrea. areas	Indust. areas	Roads	Total
Buffels (West)	1944		0,84	16,37	5,74			5,62	10,14					0,16	38,87
	1979		0,66	4,66	0,68			2,34	28,98			0,44		0,26	38,02
Elsies	1944	†						1,69	4,36		3,51			1,36	38,43
	1958		0,35	15,10	12,06			2,08	10,24		3,81			1,16	38,19
	1979	0,33	0,33	8,06	12,18			1,02	9,37		6,78	0,46		3,36	36,76
Silvermine	1944		0,36	4,86	2,61	7,94									
	1944	0,20		24,40	1,26	4,62		2,33	8,16		1,92	0,19		1,84	44,92
	1958	0,32		11,14	7,93	4,78		0,66	11,50		5,38	0,29		1,76	43,76
Sand	1979	0,02		4,90	14,25	2,73		0,45	7,07		5,50	3,18		1,67	39,77
	1944	3,04		6,22	9,93	10,43			1,29		11,28	2,23		2,25	46,97
	1958	5,52		4,04	4,23	7,54			5,79		15,04	3,79	0,15	2,46	48,56
Zeekoe	1979	7,02		5,32	2,02				0,05		18,13	13,99	0,85	0,31	47,69
	1938			21,64	23,36				3,27						48,27
Eerste	1958	2,68		13,26	27,36	0,24			6,24					0,62	50,06
	1979	1,28		12,36	7,79	0,50			7,41				22,10	0,63	52,07
	1938			19,95	17,55	2,58			12,80						53,71
Lourens	1953			11,94	9,15	2,91			24,46						48,46
	1979	6,38		5,16	3,29	2,70			7,18				26,09		50,80
	1938	3,73		4,90	5,81	0,08			8,26						32,07
	1953	2,13		10,57	5,18	0,08			5,10	3,11	2,30	2,78	0,19	0,91	37,23
Sir Lowry's Pass	1979	1,41		5,63	1,50	0,14			3,35	2,96	3,06	1,89	5,71	0,55	33,69
	1938			6,51	0,30					9,89	3,12	3,86	8,68	0,55	19,82
	1961	0,13		2,36	3,31				0,05	9,61	5,98				21,44
Steenbras	1979	0,19		2,45					0,62		12,85				19,97
	1938	0,40	4,45	0,40			2,23	38,77	0,17						47,36
Rooiels	1979	0,26	2,28	0,48			2,78	35,48	1,17					0,57	44,34
	1938	1,74	0,77	11,72	4,15	4,09		21,06							43,58
Buffels (East)	1979	2,03	0,44	8,06	3,69	5,84		21,63	0,70		0,16	0,56		0,95	44,06
	1938	9,77	0,40	6,12	8,66	1,47		16,81	0,24					0,22	43,68
	1979	4,59	0,55	6,46	6,78	1,70		11,61	2,66		0,90			2,43	47,68
Total	1938/44	19,71	6,81	133,33	88,86	23,27	2,23	86,28	48,74	13,00	22,13	5,63	0,19	7,25	
	1979	23,18	4,29	60,34	42,61	21,55	2,78	82,53	68,56		52,89	27,75	57,72	10,73	
	% difference	+17,6	-37,0	-54,7	-52,0	-7,4	+24,66	-4,3	+40,7	-100	+138,0	+392,9	+30278,9	+48,0	

TABLE 3.—The relative environmental importance factor (I) of each mapping unit

Mapping unit	I
Water	8,2
Rocks	3,2
Sand & pioneers	1,4
Dune scrub	5,0
Wetlands	10,0
River scrub	2,8
Fynbos	4,8
Alien vegetation	-6,0
Farm areas	-8,75
Residential areas	-6,0
Recreational areas	-5,25
Industrial areas	-9,5
Roads	-6,0

Three biologists involved in coastal management and two botanists involved in coastal ecology were asked to evaluate the mapping units without the study area being named. Each assessor was asked to give each unit a relative value from -10 to 10 according to how an increase in the unit would affect the functioning of the estuary and immediate environs (a negative value would mean a detrimental effect on the environment). The values thus obtained were averaged for each unit to obtain a relative environmental importance factor (I) for each mapping unit (Table 3).

Table 3 shows that the panel used for this study determined that the most important beneficial change that can occur at an estuary is an increase in wetland vegetation. Wetland vegetation is generally accepted as being beneficial to the functioning of an estuary, performing functions such as flood attenuation, silt trapping, reduction of excess nutrients, provision of breeding sites, production of food, and others (see Walmsley & Botten 1987).

An increase in wetland areas is related to water flow. An increase in water surface area was regarded as the second most important beneficial change in an estuary. Provisos concerning the quality of the water and reasons for its increase were attached to this selection.

Increases in dune scrub and other terrestrial vegetation types were given similar ranks with respect to their beneficial I values. Increases in other natural environments (e.g. rocks and sand) were perceived as being less beneficial.

All developments which result in a loss of natural environments were taken to be detrimental to estuarine functioning. An increase in industrial areas was regarded as the most detrimental. Not only does this type of development physically destroy the natural environment, but it also produces pollutants and utilizes water in various ways.

An increase in farming activities was also regarded as highly detrimental. The effects of agriculture on the estuarine environment are similar to those mentioned above.

Residential developments (including road and rail developments) and infestation by alien plants were regarded as having detrimental effects of a similar magnitude.

An increase in recreational areas was regarded as the least destructive, although it still had a relatively high negative value. The magnitude of these negative values can be related to the rate and extent to which these developments bring about a detrimental effect on the functioning of estuaries.

2 Relative environmental state (E)

As each mapping unit has a relative importance value, the relative environmental state of each study site can be determined for each year, according to the area of each mapping unit present. This was accomplished by first adding eleven to each relative importance factor to obtain positive values. Secondly, each of these positive values was multiplied by the area of the mapping unit for each estuary for each year. Thirdly, all the values thus obtained were summed for each estuary for each year. This sum was divided by the total corrected area studied at each estuary for each year to result in a measure of the environmental state (E) of each estuary for each year of observation (Table 4).

3 Coefficient of change (A)

When planning management policies, it is important to have an indication of the environmental state and the amount of change which has taken place at the study site (as shown above). However, it is particularly useful, especially for conservation policies (Roome 1984), to determine the present state of the environment in terms of its historical state and thus the amount of change that has taken place relative to each site. This was accomplished by establishing a coefficient of change (A) for each study site. For each mapping unit, the area present in 1938/44 was subtracted from the area present in 1979. This difference was divided by the sum of the total areas of the study site for these two years and multiplied by the relative environmental importance factor (I) for each unit. The values thus obtained were summed for each study site. This resulted in a coefficient of change presented in Table 4.

4 Conservability (C)

Even though very little detrimental change might have occurred at an estuary during this period of photography, it is possible that the estuary is not well suited to conservation because very little natural environment was present at the time the first aerial photographs were taken. Calculations thus far do not take the original state of the estuary into account.

This was rectified by establishing a factor arbitrarily termed 'conservability' (C). This was achieved by obtaining positive values for each coefficient of change by arbitrarily adding five to each value of A (the values for A varied from 0 to -3,35). This positive value was multiplied by the environmental state (E) of each study site for 1938/44. The values of C are presented in Table 4.

CHANGES OBSERVED IN DIFFERENT ENVIRONMENTS

As can be seen from Table 2, profound changes have occurred in land use around the estuaries entering False Bay.

Water and wetlands

Water surface area has shown a 17,6% increase during this period of photography. This could be seen as an indication of an increase of water entering the rivers from hard surface run off and sewage works. However, the factors affecting the surface area of water in an estuary are numerous and varied. This area can be affected by the season and time of photography with respect to tides and annual rainfall variability in the catchment. This variability can be illustrated by observing the photographs of 1987. These photographs show that at the Rooiels River, an increase in water surface area has resulted in a loss of open sand. The opposite has occurred at the Buffels (East) River where there has been an increase in open sand areas.

Direct comparisons of water surface area from different photographs is not recommended unless these variables can be correlated. On the other hand, wetland areas are affected by water flow characteristics. Changes in the extent and distribution of wetlands reflect long-term changes in hydrological characteristics. Even though there has been extensive physical destruction of wetlands (especially at the Sand River), wetlands in this study area have only decreased by 7,4%. With the exception of Silvermine, Sand (physical destruction) and Buffels (West), (at Steenbras wetlands absent), wetlands have increased at all the rivers. This indicates a long-term increase in the amount of water flowing into these rivers.

By 1979, a wetland of 7,94 ha had become established at the Elsies River estuary. Prior to 1910, this river flowed directly to the sea, or might have formed a small lagoon, usually in winter, which persisted for varying periods (E. McKie pers. comm.; D. de Villiers pers. comm.). The building of rail and road embankments across the river mouth (\pm 1910) restricted water flow, although water could still enter the sea via a culvert at the southern end of the beach and by seepage. By 1958, the road had been rebuilt and the base and embankments were presumably improved. It is likely that this development would have further reduced seepage, and, together with increased run off from hard surfaces, caused the wetland to become established.

Around the Silvermine River estuary, there has been a reduction of 1,89 ha in wetland areas between 1944 and

1979 (Table 2). During earlier years, the lower part of this river formed a marshy wetland (Dickson 1974; Burman 1962). However, the river in these parts has been channelled in recent years (Heineken 1982a).

Wetland vegetation has disappeared from the study site at the Sand River. The manipulations which changed the configuration of this vlei are summarized by Morant & Grindley (1982). By 1961, 32 ha of vegetated wetlands had been destroyed by dredging in this vlei and, by 1981, more than 100 ha of wetlands had been destroyed by further dredging, and residential and recreational developments.

There has been an increase of 0,50 ha in wetland vegetation at the Zeekoe River estuary (Table 2). This river was constructed in 1942 as an overflow channel for Zeekoevlei (Bickerton 1982). By 1944, an estuarine lagoon had formed on the beach. The coastal road (Baden-Powell Drive) had restricted this lagoon to the hind-dune area by 1958 and the development of the sewage works in the early 1960s (Summers *et al.* 1976) increased the water flow in this river, thus allowing the wetlands to increase.

The increase in wetlands measured for the Eerste River estuary between 1938 and 1958 could be related to the decrease in water surface area for this period (Table 2). However, there was a large increase in water surface area between 1958 and 1979, caused by increased run off due to developments in the catchment and the discharge of treated sewage effluent.

Prior to a bridge being built across the Rooiels River mouth in the early 1950s, this river followed a meandering course across the floodplain (Heineken 1982b). This bridge relocated the main flow channel towards the northern side of the floodplain. A meander was re-established on the seaward side of the road and the damming effect of this bridge brought about a slight increase in wetland area (Table 2).

In 1938, the Buffels (East) River formed a large backshore lagoon. The considerable reduction of this lagoon was probably facilitated by the enlargement of the Buffels Dam in 1972 (Heineken *et al.* 1982).

Dune vegetation

During this period, units 3 (sand and pioneers) and 4 (dune scrub) have decreased by approximately 50% each. The most widespread reason for this decrease is the growth of alien plants, which were found at all the rivers by 1979. At the Cape Flats estuaries (Zeekoe, Eerste, Lourens), industrial development is the most important factor contributing to the demise of dune vegetation. At Silvermine, Sand, Rooiels and Buffels (East), residential developments were most important with recreational developments at Sir Lowry's Pass. These developments are discussed in greater detail below.

Riverine scrub and fynbos

These vegetation types were found mainly around rivers on the eastern shores of the Bay. Little development has taken place around these rivers and fynbos and riverine scrub have hardly been affected.

TABLE 4. —The environmental state (E) of each study site for each photograph of a temporal series, the coefficient of change for each study site (A) and the conservability (C) of each study site (see text for explanations)

River	E			A	C
	1938/44	1953/58/61	1979		
Buffels (West)	11,50		6,89	-2,20	31,20
Elsies	11,92	10,86	10,61	-0,66	51,93
Silvermine	11,60	10,88	11,04	-0,29	54,63
Sand	12,62	10,73	8,62	-2,10	36,60
Zeekoe	14,02	13,73	7,42	-3,35	23,13
Eerste	12,33	9,86	7,30	-2,48	31,07
Lourens	9,59	8,76	6,57	-1,27	35,77
Sir Lowry's Pass	6,22	6,36	6,19	-0,04	30,85
Steenbras	15,31		14,86	-0,37	70,88
Rooiels	15,50		15,45	0,00	77,50
Buffels (East)	16,17		14,51	-0,64	70,50

Less fynbos was present near the estuaries of the western shore in 1938. Around these rivers (Buffels (West), Elsies, Silvermine), fynbos has decreased by 60,4%, mainly as a result of alien plant invasion and residential development. Fynbos was not found around the river mouths of the Cape Flats.

FACTORS CAUSING CHANGES

Alien vegetation

By 1979, alien plants, mainly Australian acacias, were found at every study site (Table 2). Acacias were introduced into the Cape between 1845 (Shaughnessy 1980) and 1870 (Roux & Middlemiss 1963).

Official bodies, local authorities as well as central government organizations, planted alien acacias at numerous places along this coast, among others: 1885, Eerste River Mouth (Shaughnessy 1980); 1893, Retreat Station, north of the Sand River (Shaughnessy 1980); 1936, Zeekoe River, vicinity of mouth (Bickerton 1982); 1942, Sand River coast (Shaughnessy 1980).

In addition to the above plantings, Opie (1967) maintains that aliens were planted by a farmer at the Buffels (West) River during the mid-19th century to stabilize deep sands in the area (Coke 1963). Acacias might also have been planted at the lower Elsies River by the De Villiers family who have farmed the area since the 1870s. Although this farmer planted an unknown *Hakea* species (probably *H. sericea*) at the Elsies River and acacias on the western coast of the Peninsula, no record of the planting of acacias at the Elsies River exists (D. de Villiers pers. comm.).

The presence of alien plants at other sites is likely to have occurred by natural encroachment (Glyphis *et al.* 1981). At the lower Silvermine River, major encroachment seems to have occurred from the south where these plants are still used for hedges, windbreaks and shade in Fish Hoek town, established in 1918 (Burman 1977). At the Lourens River estuary, alien plants appear to have entered the study site along the river course from neighbouring farms. At the lower Steenbras River, alien plants were first found on disturbed areas near the road, while at the Rooiels and Buffels (East) estuaries, the presence of these plants can be related to the advent of residential development.

Residential development

In the area studied, there has been a 238% increase in residential areas, most of this development has taken place on the hillsides along the western and eastern shores of the Bay.

The Buffels (West) River lies within the Cape of Good Hope Nature Reserve, proclaimed in 1938. Consequently, development has been restricted to the creation of picnic sites around the tidal pool to the south of the river.

Much residential development has taken place around the lower Elsies River (93% increase), Silvermine River (186% increase) and Sand River (61% increase). These developments took place mainly at the expense of fynbos and the open sand/pioneer vegetation, although the latter

had often been dominated by alien vegetation prior to residential development. At the Sand River, most of the development has taken place on filled-in wetland vegetation.

No residential development has taken place around the estuaries of the central Cape Flats, but an increase in housing of 272% and 312% has occurred respectively at the Lourens and Sir Lowry's Pass estuaries, mainly at the cost of dune scrub and agricultural areas. Some minor developments have taken place at the lower Rooiels and Buffels (East) Rivers. These are mainly in the form of seaside cottages.

Recreational development

Recreational developments are closely allied to residential development. Some minor development has taken place around the Buffels (West) and Elsies Rivers. There has been a major increase in the percentage recreational area at the Silvermine River in the form of the golf club. The golf course covers approximately 3 ha of what was previously farmland, open sand and dune scrub. The 504% increase in recreational area at the Sand River has been in the form of tended parklands on what was previously wetlands. A caravan site of 3,8 ha has been developed at the lower Sir Lowry's Pass River at the expense of dune scrub and open sand. Although the steep topography around the Steenbras River is not suited to residential development, recreational development has proceeded in this area and, in 1979, consisted of 1,3 ha of the study site. Minor developments in the form of picnic sites have taken place at the lower Rooiels River.

Industrial development

Major industrial development seems to be restricted to the rivers of the Cape Flats, away from the major residential and recreational areas. At the Sand River, a small nursery has been established near the head of the vlei, hardly compatible with residential and recreational development. The major industrial developments have been in the form of sewage treatment works: 22,10 ha at the lower Zeekoe River and 26,09 ha at the lower Eerste River. The 8,65 ha of industrial development at the Lourens River is in the form of a buffer and security zone around a chemical and explosives factory. Although very few buildings have been erected in this area, it is prone to environmental destruction and invasion by alien plants.

DISCUSSION OF INDIVIDUAL ESTUARIES

Buffels (West)

The low conservability of this estuary can be explained by a single factor: the encroachment of alien plants. Early aerial photographs and historical records show that this river valley consisted of a sand plume, and sediment interchange took place with the near-shore environment (Heineken *et al.* 1982). Sparse dune pioneers and dune scrub would have been found on this sand. Between 1944 and 1978, open sand and pioneers decreased by 71,5%; dune scrub decreased by 88,2%; and fynbos decreased by 58,3%. During this period, alien plant cover increased by 185,8%.

The removal of alien plants from this reserve is an ongoing policy of the local authorities, but with varying success rates. MacDonald *et al.* (1989) quote reports which state that this area was completely cleared of aliens in 1945 and again in 1959. However, the 1979 photographs show that the area was again heavily infested. The 1987 colour aerial photographs show that approximately 2 ha of alien plants had been removed from this site and dune pioneers and scrub had re-established. These developments will serve to increase the conservability of this river.

Elsies

At this estuary, major impacts have been due to the encroachment of alien plants (114,9% increase) and residential developments (including roads: 108,2% increase). Open sand and pioneers, and dune scrub have decreased by 67,8% and 78,4% respectively. These changes should have had the effect of somewhat decreasing the conservability. However, a wetland has formed in areas which were previously sand and dune vegetation. As wetlands were given a higher relative importance factor (I) (Table 3), this development has ameliorated the decrease in conservability.

Photographs taken during 1987 show that little change has taken place at this site. However, residential development is taking place in the vicinity which could bring about an increased run off from hard surfaces, further affecting the wetland.

Silvermine

Around the lower part of this river, open sand and pioneer vegetation, and fynbos has decreased by 79,9% and 40,9% respectively. Residential and recreational developments have increased by 186,5% and 157,4% respectively. However, much of this development has taken place in areas which were previously dominated by alien plants. This has led to a net decrease in alien plant cover of 13,4% over the period covered by the aerial photography (in 1958, alien plant cover was 38,5% greater than in 1979). Furthermore, dune scrub has established in areas which were previously open sand. These environmental changes ensure that the conservability of this area remains relatively high.

Aerial photographs of 1987 show that a further 5 ha of dune vegetation has been destroyed by residential developments.

Sand

The major development that has taken place at the Sand River is a 527% increase in recreational areas. This has led to the almost total elimination of wetland vegetation and a 79,7% decrease in dune scrub. Some of the residential (60,7% increase) and recreational development has taken place in areas that were previously dominated by alien vegetation, resulting in a decrease in alien vegetation of 96,1%.

The conservability of this estuary is comparable to those of the other four estuaries of the Cape Flats (Zeekoe, Eerste, Lourens, Sir Lowry's Pass). The reasons for the

low value of C for the Sand River are, however, unique, due primarily to recreational developments.

Zeekoe

This estuary has the lowest conservability and the highest coefficient of change. The major reasons for this are the establishment of sewage settling ponds (22,1 ha) and a 126,6% increase in alien vegetation. Dune scrub and open sand and pioneers have decreased by 66,7% and 42,9% respectively.

The construction of the settling ponds destroyed large areas of dune scrub, but they are no longer used, except possibly in emergencies. They have become an important coastal habitat for water birds and recommendations have been made for these ponds to be proclaimed as a nature reserve (Curtin *et al.* 1975; Cooper *et al.* 1976; Brummer 1981; Bickerton 1982). If this proclamation were to take place, these ponds might be regarded as open water. This estuary would then be the only one along False Bay with a positive coefficient of change, resulting in a conservability of 80,8%. This would be an artificially induced beneficial change and might serve to mask detrimental changes in the area.

The 1987 photographs show that approximately 4 ha of land have been cleared, presumably for low-cost housing. This has brought about a loss of dune scrub and some alien vegetation.

Eerste

The reasons for the low conservability of this estuary are similar to those discussed for the Zeekoe River estuary: the establishment of a sewage works of 26,09 ha. This development resulted in a decrease in dune scrub and open sand and pioneers of 81,3% and 74,1% respectively. Alien shrubs have long been established in this area (Shaughnessy 1980) and the construction of this sewage works served to decrease alien vegetation by 43,9%.

Another factor serving to increase the conservability is a 668,7% increase in estuarine water surface area. Although tidal and climatic factors might have led to this observed increase of water surface area on the photographs, large areas of the catchments of the Eerste River and Kuils River (a tributary) have become developed over the last decades (Grindley 1982). Increased run off from hard surfaces as well as effluent discharge from at least five sewage works in this catchment have undoubtedly increased the amount of water flowing into the sea via this estuary.

At this river, photographs taken in 1987 show that approximately 2 ha of alien plants have been cleared in what was previously classified as industrial areas.

Lourens

There has been a 4 468,4% increase in industrial area and a 272,6% increase in residential area around this estuary. In addition, there has been a 74,2% demise of dune scrub. These developments would serve to decrease the conservability. However, they have resulted in a net

decrease of alien vegetation (59,4%) and agriculture which has disappeared from this area. There has also been a slight increase in open sand and wetland vegetation, factors which would increase the conservability.

Nevertheless, the conservability of this estuary was relatively low when aerial photography began in 1938. The conservability of this estuary remains low, even though the coefficient of change (A) is lower than for most of the estuaries of the Cape Flats.

The 1987 photographs show that some eradication of alien plants has taken place within industrial areas. But outside of these areas, approximately 1 ha of open sand has been consolidated by alien shrubs.

Sir Lowry's Pass

Even though the coefficient of change for this estuary is close to zero, this estuary does not have a high conservability. This is because much of the area had been developed by the time of onset of photography for this study. In 1938, most of this area was used for agricultural purposes. By 1979, these agricultural areas had been converted to residential areas. Between 1938 and 1961, dune scrub had become established on much of the open sand and pioneer vegetation. By 1979, this dune scrub had largely been destroyed for recreational purposes.

Steenbras, Rooiels and Buffels (East)

Most of the changes that took place around these estuaries were discussed above. These changes are relatively minor, as can be seen from the high conservability values. However, they all show slight increases in alien plant cover, residential and/or recreational areas, with decreases in the natural dune vegetation.

Photographs taken in 1987 show that these developments are ongoing. Some recreational and residential development has taken place at the Steenbras and Buffels (East) Rivers. There have also been slight increases in alien scrub at the Rooiels and Buffels (East) Rivers. Soon after these latest photographs were taken, major upgrading of the main thoroughfare across the Rooiels River was commenced. The stage could be reached when these developments may destroy the attractiveness of these areas, i.e. the natural environment. This, unfortunately, is largely the pattern observed along the western shores of the Bay.

COMPARISON OF ESTUARIES

The effects of development can be determined by using the descriptive methods discussed under Methods: evaluation of changes. However, quantitative measurements, or environmental values, are often needed to compare different areas and to facilitate decision-making.

Table 3 shows that the environmental state of all the estuaries decreased during the period spanned by aerial photography. When the first aerial photographs were taken, the most easterly rivers of the Cape Flats (Lourens and Sir Lowry's Pass) had the lowest E value (9,59 and 6,22 respectively) whereas the highest E value was found at the Buffels (East) River (16,17). In 1979, this range for E values was similar (6,19 at Sir Lowry's Pass; 15,45 at Rooiels).

However, the environmental state of the other rivers of the Cape Flats (Sand, Zeekoe, Eerste) had deteriorated so as to be in accordance with Lourens and Sir Lowry's Pass. The state of the Buffels (West) River had also deteriorated drastically.

This deterioration of the environmental states of these rivers is further demonstrated by the coefficient of change (A). The value of A for all the rivers is negative for the period covered by the aerial photography. The most change has taken place at the Zeekoe River ($A = -3,35$). The changes that have taken place at the lower Rooiels River are minor and A is given as zero.

Although conservability (C) is a relative factor, it is possibly the most important as it integrates all the factors calculated above. The lowest value of C is seen at the Zeekoe River estuary (23,13) where much industrial development and invasion by alien plants has taken place. The Rooiels River estuary has the highest value for C (77,50). Only a small amount of recreational and residential development has taken place at this estuary and the environment retains a healthy state.

The estuaries of the Cape Flats (Sand to Sir Lowry's Pass) have the lowest C values. The C values for the estuaries on the western side of the Bay (Buffels (West) to Silvermine) are lower than those on the eastern side of the Bay (Steenbras to Buffels (East)). This is understandable as, being closer to the city of Cape Town, the western side of the Bay would be in greater demand for housing and other developments.

CONCLUSIONS

Aerial photographs are readily available for large parts of the coast. For False Bay, these photographs span a period between 1938/44 and 1987. The environmental coefficients presented here are easily and rapidly calculated. They give quantitative indications of the state of the environment and can be used to facilitate decision-making and policy formulation. For example, using the data presented above, management of the most easterly rivers of False Bay should be orientated towards conservation while smaller sanctuaries could be established at the Elsie and Silvermine Rivers, particularly the wetland areas. The rivers of the Cape Flats should be managed as developed areas and attempts should be made to remove alien plants from the Buffels (West) River.

A similar exercise can be carried out for the entire coastline of False Bay. Communication between local governmental bodies could establish an integrated management policy for this coast with little expenditure in terms of time, effort and equipment.

The results of such an exercise must, however, be analysed critically. Without some understanding of the reasons for changes in these environmental factors, erroneous conclusions can be reached. For example, a large part of the observed increase in water surface area at the Eerste River is due to an increased run off from developments in the catchment. The observed increase in water surface area at the Rooiels River is more likely due to climatic phenomena. Furthermore, if it was decided that

residential developments were more detrimental to the environment than agricultural developments, the environmental state (E) of the Sir Lowry's Pass River would have decreased from 1938 to 1961. Any statement concerning the importance of any part of the environment is subjective and could thus be a source of error. Although data could be collected by non-specialists, it is recommended that environmental evaluation be carried out by specialists or evaluation panels (Fuggle 1983).

REFERENCES

- BICKERTON, I.B. 1982. Report No. 15: Zeekoe (CSW 5). In A.E.F. Heydorn & J.R. Grindley, *Estuaries of the Cape, Part II: synopses of available information on individual systems*. CSIR Research Report No. 414.
- BOUCHER, C. 1978. Cape Hangklip area. II. The vegetation. *Bothalia* 12: 455–497.
- BOUCHER, C. 1987. *A phytosociological study of transects through the western Cape coastal foreland, South Africa*. Ph.D. thesis, University of Stellenbosch.
- BRUMMER, T.B. 1981. *A development plan for the Zeekoevlei complex*. M.Sc. thesis, University of Stellenbosch.
- BURMAN, J. 1962. *Safe to the sea*. Human & Rousseau, Cape Town.
- BURMAN, J. 1977. *The False Bay story*. Human & Rousseau, Cape Town.
- COKE, M. 1963. *An ecological study of the extent of alien infestation of the Good Hope Nature Reserve and its spread over the years 1952–1961*. Botany Department, University of Cape Town. Unpublished.
- COOPER, J., SUMMERS, R.W. & PRINGLE, J.S. 1976. Conservation of coastal habitats of waders in the south-western Cape, South Africa. *Biological Conservation* 10: 239–247.
- CURTIN, R., AQUADRO, D., HILL, R. & UPSHER, S. 1975. *Management proposals for Zeekoevlei*. School of Environmental Studies, University of Cape Town. Unpublished.
- DICKSON, D. 1974. *A short history of Clovelly Country Club*. Clovelly Country Club. Unpublished.
- FUGGLE, R.F. 1983. Environmental evaluation. In R.F. Fuggle & M.A. Rabie, *Environmental concerns in South Africa*: 483–515. Juta, Cape Town.
- GASSON, B. ed. 1980. *Proceedings of seminar on The future management of False Bay*. Cape Town.
- GLYPHIS, J.P., MILTON, S.J. & SIEGFRIED, W.R. 1981. Dispersal of *Acacia cyclops* by birds. *Oecologia* 48: 138–141.
- GRINDLEY, J.R. 1982. Report No. 16: Eerste (CSW 6). In A.E.F. Heydorn & J.R. Grindley, *Estuaries of the Cape, Part II: synopses of available information on individual systems*. CSIR Research Report No. 415.
- HEINECKEN, T.J.E. 1982a. Report No. 13: Silvermine (CSW 3). In A.E.F. Heydorn & J.R. Grindley, *Estuaries of the Cape, Part II: synopses of available information on individual systems*. CSIR Research Report No. 412.
- HEINECKEN, T.J.E. 1982b. Report No. 8: Rooiels (CSW 10). In A.E.F. Heydorn & J.R. Grindley, *Estuaries of the Cape, Part II: synopses of available information on individual systems*. CSIR Research Report No. 407.
- HEINECKEN, T.J.E., BICKERTON, I.B. & MORANT, P.D. 1982. Report No. 12: Buffels (wes) (CSW 1), Elsie (CSW 2), Sir Lowry's Pass (CSW 8), Steenbras (CSW 9) and Buffels (oos) (CSW 11). In A.E.F. Heydorn & J.R. Grindley, *Estuaries of the Cape, Part II: synopses of available information on individual systems*. CSIR Research Report No. 411.
- HELMER, O. 1963. *The systematic use of expert judgement in operations research*. The Rand Corporation P-2795.
- LINSTON, H.A. 1975. *The Delphi method*. Addison-Wesley, London.
- MACDONALD, I.A.W., CLARK, D.L., TAYLOR, H.C. 1989. The history and effects of alien plant control in the Cape of Good Hope Nature Reserve, 1941–1987. *South African Journal of Botany* 55: 56–75.
- MALAN, J. 1982. *The formulation of an administrative structure for the management of False Bay*. University of Cape Town, School of Environmental Studies, Report No. 35.
- MOLL, E.J., CAMPBELL, B.M., COWLING, R.M., BOSSI, L., JARMAN, M.L. & BOUCHER, C. 1984. *A description of major vegetation types in and around the Fynbos Biome*. South African National Scientific Progress Report No. 83.
- MORANT, P.D. & GRINDLEY, J.R. 1982. Report No. 14: Sand (CSW 4). In A.E.F. Heydorn & J.R. Grindley, *Estuaries of the Cape, Part II: synopses of available information on individual systems*. CSIR Research Report No. 413.
- O'CALLAGHAN, M. 1985. *Vegetation and land-use data collection techniques for environmental management purposes, with particular reference to the rivers entering False Bay, Cape, South Africa*. M.Sc. thesis, University of Cape Town.
- O'CALLAGHAN, M. 1990. The ecology of the False Bay estuarine environments, Cape, South Africa. 1. The coastal vegetation. *Bothalia* 20: 105–111.
- OPIE, F.W.S. 1967. *The ecology and geographical development of the Cape Point area*. Geography Department, University of Cape Town. Unpublished.
- ROOME, N.J. 1984. Evaluation in nature conservation decision-making. *Environmental Conservation* 11: 247–252.
- ROUX, E.R. & MIDDLEMISS, E. 1963. The occurrence and distribution of *Acacia cyanophylla* and *A. cyclops* in the Cape Province. *South African Journal of Science* 59: 286–294.
- SANDBACH, F. 1980. *Environmental ideology and policy*. Blackwell, London.
- SCHROEVERS, S.P. 1982. Diversity in nature as an expression of social and economic circumstances. In S.P. Tjallingii & A.A. de Veer, *Perspectives in landscape ecology*: 74–77. Centre for Agricultural Publication and Documentation, Wageningen.
- SHAUGHNESSY, G.L. 1980. *Historical ecology of alien woody plants in the vicinity of Cape Town, South Africa*. Ph.D. thesis, University of Cape Town.
- STIRTON, C.H. 1978. *Plant invaders—beautiful, but dangerous*. Department of Nature Conservation, Cape Provincial Administration, Cape Town.
- SUMMERS, R.F., PRINGLE, J.S. & COOPER, J. 1976. *The status of coastal waders in South Africa*. Percy Fitzpatrick Institute of African Ornithology, Rondebosch.
- TAYLOR, H.C. 1969. *A vegetation survey of the Cape of Good Hope Nature Reserve*. M. Sc. thesis, University of Cape Town.
- TAYLOR, H.C. 1980. Plant communities along the False Bay coast. In B. Gasson, *Proceedings of seminar on The future management of False Bay*: 59–67. Cape Town.
- WALMSLEY, R. D. & BOTTEN, M.L. 1987. *Ecology and conservation of wetlands in South Africa*. CSIR Occasional Report No. 28.

Miscellaneous note

VARIOUS AUTHORS

NOTES ON THE DISTRIBUTION AND HABITAT OF *ALOE BOWIEA* (LILIACEAE/ASPHODELACEAE: ALOOIDEAE), AN ENDANGERED AND LITTLE KNOWN SPECIES FROM THE EASTERN CAPE

A. bowiea is an extremely rare species only known from a limited area in the eastern Cape. Under conditions of normal rainfall it is a dwarf rosulate leaf succulent (sensu Newton 1974), reaching a height of 300 mm at the flowering stage.

Morphologically and taxonomically *A. bowiea* is insufficiently known. A study on these aspects is in progress and will be reported elsewhere.

HABITAT

Geographical situation

Aloe bowiea is known only from the three study sites discussed below (Figure 1). Locality 1 is located south of Uitenhage, between Uitenhage and Despatch, on the farm 'Jachtlvakte'. Locality 2 is situated at Coega, approximately 25 km east of Uitenhage, on 'Maasward', a private nature reserve bordering the Uitenhage–Sundays River mouth road. Locality 3 is on the farm 'Brakkefontein', 20

km from the Kirkwood turn-off on the Uitenhage–Jansenville road. These localities will subsequently be referred to as Uitenhage, Coega and Kariega, respectively. Although the population of *A. bowiea* at Uitenhage, still thriving in 1983, is now considered extinct, this locality will be included in this paper. Hitherto this species was only known from the latter locality.

Climate

The climate at the three study sites is warm temperate and conforms to the semi-arid valley climate recognized by Cowling (1983a) for the river valleys of the south-eastern Cape.

At Uitenhage the average annual rainfall is 435 mm with monthly maxima in April, August and November and minima in the summer and winter months. Temperatures are moderate with all months being between 13° and 23°C. Coega and Kariega (Figure 2: Hermitage and Hillside Farm respectively) experience a warmer and more arid

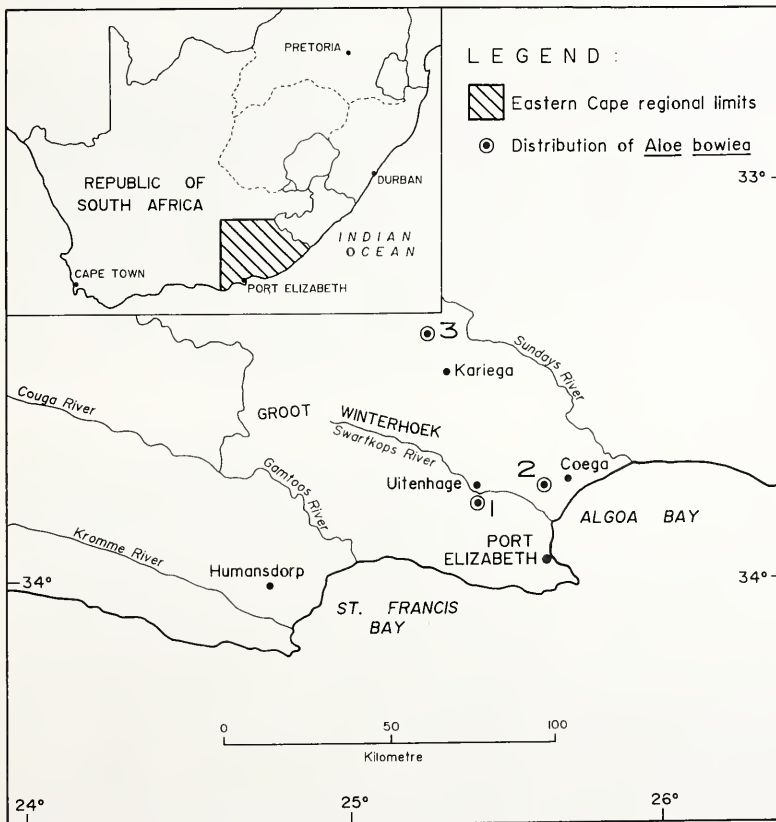


FIGURE 1.—Map showing the regional limits of the eastern Cape (after Lubke *et al.* 1986) and the three known localities of *Aloe bowiea*. In recent years the species has become extinct at locality 1.

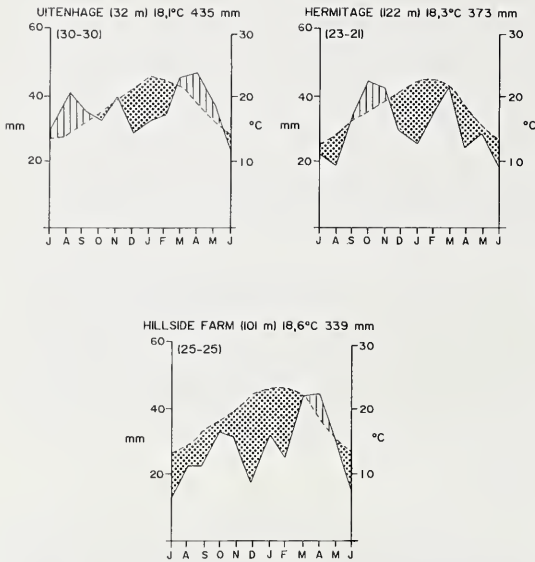


FIGURE 2. —Walter-Lieth climate diagrams of selected stations. Data from Weather Bureau (1984).

climate. Rainfall is generally erratic with an average annual figure of 373 mm at Hermitage and 339 mm at Hillside Farm. Both sites have a bimodal distribution of rain, with peaks in autumn and late spring. At these sites the mean monthly temperatures show a slightly greater range (13–24°C) with maximum temperatures exceeding 40°C and minima dropping below 0°C.

Vegetation

Field observations at all the localities have shown that *Aloe bowiea* is restricted to the Sundays River Scrub variation of Valley Bushveld [Veld Type 23 sensu Acocks (1988)] of the Uitenhage, Coega and Kariega regions in the south-eastern Cape. Acocks (1988) did not specifically mention the vegetation surrounding Uitenhage, Coega and Kariega, but at all localities it would, on the ground of shared *Euphorbia* species, fit into his Sundays River Scrub variation. On the map which accompanied Acocks (1988) the vegetation of this area is given as Valley Bushveld. Other authors have referred as follows to the vegetation with which *A. bowiea* is associated: Thicket (Jessop & Jacot Guillarmod 1969), Addo Bush (Penzhorn & Olivier 1974), Valley Bushveld (sensu Olivier 1977, 1981; Moll *et al.* 1984), Subtropical Transitional Thicket (Cowling 1984; Everard 1987), Subtropical Transitional Thicket, including Valley Bushveld (sensu Lubke *et al.* 1986) and Subtropical Thicket (Van Wyk *et al.* 1988a, 1988b). This vegetation type is confined mainly to the valleys of rivers which flow east and drain into the Indian Ocean, and currently covers approximately 15% of the eastern Cape (Everard 1987). These valleys are relatively hot and dry in comparison to the intervening ridges.

The Valley Bushveld vegetation at both the Uitenhage and Coega localities included in the present study forms a dense and, where undisturbed, almost impenetrable thicket. It agrees with the differentiating characters given by Everard (1987) for Mesic Succulent Thicket in having a mean total cover of about 90%, an average canopy height

of about 2.5 m and a large proportion of succulents (more than 20%). At the Kariega locality the vegetation is less dense (average total cover of approximately 60%) with a slightly lower shrub canopy (2.0–2.5 m) and succulents comprise about 30% of the species. This locality falls within the Xeric Succulent Thicket suborder. Succulents associated with *A. bowiea* include, at Uitenhage: *Aloe africana* Mill., *A. striata* Haw., *Bulbine caulescens* L., *B. latifolia* Roem. & Schult., *Euphorbia stellata* Willd., *E. meloformis* Ait., *E. globosa* (Haw.) Sims and *Pachypodium succulentum* (L. f.) A. DC.; at Coega: *Aloe ferox* Mill., *Gasteria maculata* (Thunb.) Haw., *Haworthia xiphiophylla* Bak., *Euphorbia meloformis*, *E. clava* Jacq., *E. ledienii* Berger and *Pachypodium succulentum* and at Kariega: *Bulbine latifolia*, *Haworthia sordida* Haw. (M.B. Bayer pers. comm.), and *Haworthia* sp. cf. *cooperi* Bak. At all three localities species of *Coryledon* L., *Crassula* L. and the Mesembryanthemaceae occur in large numbers.

Although the vegetation at the three localities where *Aloe bowiea* is known to occur can be broadly classified as thicket, plants of this species have never been encountered in the shade of surrounding vegetation. It seems to be restricted to ecological niches where the valley bush opens up naturally to form a less dense karroid/grass community. These breaks in the canopy layer do not appear to be man-induced (at least in recent times) since they also occur in nature reserves which lie within valley bush, such as Springs Reserve at Uitenhage and Maasward Private Nature Reserve at Coega. As a result of litter decomposition the soils on which thicket occurs usually contain high levels of organic matter. *Aloe bowiea* was not recorded from these humic soils.

ENDEMISM

Everard (1985) lists only three species of *Aloe* as being endemic to the eastern Cape, namely, *A. africana*, *A. tidmarshii* and *A. bowiea*. On the other hand Cowling (1982, 1983b) states that five of the 25 species of *Aloe* indigenous to the eastern Cape are endemic to this region. For *A. bowiea* Cowling (1982, 1983b) prefers to uphold the name *Chamaealoe africana*. The discrepancies in the literature with regard to the number of *Aloe* taxa indigenous or endemic to the eastern Cape (Cowling 1982, 1983b; Everard 1985; Gibbs Russell & Robinson 1981; Holland 1978) can be explained by the different delimitation of the eastern Cape by the different authors.

CONSERVATION

According to Everard (1985) the eastern Cape currently has 662 threatened taxa. Of these, 485 are listed in the category **uncertain whether safe or not**. This conservation status category is defined as one for plants that are so little known that there is an even chance that they could prove to be safe. Everard (1985) listed *Aloe bowiea* in this category. Field observations during recent years have, however, revealed only three localities for this species. Moreover, the population of *A. bowiea* at Uitenhage is now extinct and at both Coega and Kariega the populations are vulnerable and declining. With the exception of the Coega locality, where *A. bowiea* occurs in a privately owned nature reserve, none of the known populations are conserved. This species takes readily to cultivation, but it is horticulturally unattractive and poorly represented in

succulent plant collections. The distribution of known populations of *A. bowiea* is shrinking fast. For example, whereas in 1983 the population at Uitenhage comprised 141 individuals, no plants could be found at this locality in 1988.

CONCLUSION

Recent field observations have shown that *Aloe bowiea* has a very limited geographical distribution and that it is now extinct at Uitenhage, the only previously known locality. At the other two localities, Coega and Kariëga, the populations of *A. bowiea* are endangered and should be added as such to the list published by Everard (1988).

It is recommended that populations be securely fenced to prevent game animals and domestic stock from grazing individuals of this species. This would allow plants to flower and set seed and could ultimately lead to the expansion of existing populations and the establishment of new ones. Unless immediate action in the form of land acquisition and the education of land owners are taken, this unique and localized species of the karroid vegetation of Valley Bushveld may soon be extinct in nature.

ACKNOWLEDGEMENTS

Discussions with Prof. G.J. Bredenkamp contributed substantially to the formulation of a conceptual basis for this paper. Many of the observations reported here were made while the first author was an undergraduate student at the University of Port Elizabeth and he therefore makes acknowledgement to this institution.

REFERENCES

ACOCKS, J.P.H. 1988. Veld types of South Africa, 3rd edn. *Memoirs of the Botanical Survey of South Africa* No. 57.
COWLING, R.M. 1982. Patterns of plant endemism in the south-eastern Cape. *The Naturalist* 27: 17–20.
COWLING, R.M. 1983a. Diversity relations in Cape shrublands and other vegetation in the south-eastern Cape, South Africa. *Vegetatio* 54: 103–127.
COWLING R.M. 1983b. Phytochorology and vegetation history in the south-eastern Cape, South Africa. *Journal of Biogeography* 10: 393–419.

COWLING, R.M. 1984. A syntaxonomic and synecological study in the Humansdorp region of the Fynbos Biome. *Bothalia* 15: 175–227.
EVERARD, D.A. 1985. *Conservation status of some unique plant communities and floral elements in the eastern Cape*. M.Sc. thesis, Rhodes University, Grahamstown.
EVERARD, D.A. 1987. A classification of the subtropical transitional thicket in the eastern Cape, based on syntaxonomic and structural attributes. *South African Journal of Botany* 53: 329–340.
EVERARD, D.A. 1988. Threatened plants of the eastern Cape: a synthesis of collection records. *Bothalia* 18: 271–277.
GIBBS RUSSELL, G.E. & ROBINSON, E.R. 1981. Phytogeography and speciation in the vegetation of the eastern Cape. *Bothalia* 13: 467–472.
HOLLAND, P.G. 1978. An evolutionary biogeography of the genus *Aloe*. *Journal of Biogeography* 5: 213–226.
JESSOP, J.P. & JACOT GUILLARMOUD, A. 1969. The vegetation of the Thomas Baines Nature Reserve. *Journal of South African Botany* 35: 367–392.
LUBKE, R.A., EVERARD, D.A. & JACKSON, S. 1986. The biomes of the eastern Cape with emphasis on their conservation. *Bothalia* 16: 251–261.
MOLL, E.J., CAMPBELL, B.M., COWLING, R.M., BOSSI, L., JARMAN, M.L. & BOUCHER, C. 1984. *A description of major vegetation categories in and adjacent to the Fynbos Biome*. South African National Scientific Programmes Report No. 83. CSIR, Pretoria.
NEWTON, L.E. 1974. Comments on the caudiciform cult. *National Cactus and Succulent Journal* 29: 14–17.
OLIVIER, M.C. 1977. A systematic checklist of the Spermatophyta of the Baakens River Valley, Port Elizabeth. *Journal of South African Botany* 43: 145–159.
OLIVIER, M.C. 1981. An annotated systematic checklist of the Spermatophyta of the Springs Reserve, Uitenhage. *Journal of South African Botany* 47: 813–828.
PENZHORN, B.L. & OLIVIER, M.C. 1974. A systematic checklist of flowering plants collected in the Addo Elephant National Park. *Koedoe* 17: 121–136.
VAN WYK, B-E., NOVELLIE, P.A. & VAN WYK, C.M. 1988a. Flora of the Zuurberg National Park. 1. Characterization of major vegetation units. *Bothalia* 18: 211–220.
VAN WYK, B-E., VAN WYK, C.M. & NOVELLIE, P.A. 1988b. Flora of the Zuurberg National Park. 2. An annotated checklist of ferns and seed plants. *Bothalia* 18: 221–232.
WEATHER BUREAU 1984. *Climate of South Africa. Climate Statistics up to 1984*. WB 40. Department of Environment Affairs, Government Printer, Pretoria.

G.F. SMITH* and A.E. VAN WYK**

* Department of Plant Sciences, Potchefstroom University for C.H.E., Potchefstroom 2520.

** Department of Botany, University of Pretoria, Pretoria 0002.
MS. received: 1989.06.29.

OBITUARY

MARY DAVIDSON GUNN (1899–1989)

The death of Mary Gunn on 31 August 1989 marked the passing of the last of a trio known with affection in the South African botanical world as the Three Graces. Together with her colleagues, taxonomist Inez Verdoorn (1896–1989) and botanical artist Cythna Letty (1895–1985), Mary Gunn formed a remarkable team, each member of which left an indelible mark on their respective field of botany over a working period totalling more than 150 years.

Mary Gunn was born in Kerriemuir, Scotland on 15 May 1899 (Figure 1). Her father served in a Scottish regiment in South Africa during the Anglo-Boer War and on returning home decided to immigrate to this country where he settled in Pretoria.

After attending the Gymnasium School, Mary Gunn joined the Division of Botany as a clerk with a 'knowledge of typing' as her letter of appointment indicates. It is clear from this letter that appointments were expeditiously executed at the time (Figure 2).

However, the new appointee was not constantly busy and to keep herself occupied, she would dismantle and examine the intricate workings of her wrist watch. Caught in the act by her sometimes irascible chief Dr Iltyd Buller Pole Evans, her immediate superior was instructed to give the young Scottish lass the books to take care of to fully utilize her working hours. This was to prove an inspired directive.

Mary was immediately interested in her new task although the collection of books was so small that there were not enough to fill even one shelf in the small room of the Division headquarters in 'Vredehuis' (Figure 3). On her return home each day she was enthusiastically encouraged by her father to describe each of the books she had catalogued. This daily ritual probably played a large part in the development of the remarkable memory which was to be one of her greatest attributes in the years to come.

The young librarian (Figure 4) with no formal training, was so excited by the world of botanical books to which she had so fortuitously been introduced that she began studying catalogues to establish which old works were available and how she could acquire them. She rapidly became an authority on old botanical literature and ascribed her future years of dedication largely to the pleasure derived from some of her first acquisitions. Heading the list was P.J. Bergius' *Descriptiones plantarum ex capite bonae spei*. This book, which was purchased in the 1920s from a German bookseller for a small sum, is inscribed W.H. Harvey 1838. But the real thrill about the acquisition was the fact that it had belonged to a young German, Georg Forster, who with his father had sailed on the 'Resolution' with Captain Cook on his second circumnavigation of the globe in 1772.

The delight of obtaining this type of Africana was to remain with Mary Gunn throughout her life. Many other noteworthy publications were to be purchased in the years to come. The majority of these early works were published privately and the limited copies were usually presented to patrons and friends. Colour printing was unknown and illustrations had to be hand-coloured in water colours. Fortunately Mary Gunn realized the value of works of this nature many years before it was generally appreciated in other parts of the world.

Because of very limited funds, various ways and means had to be devised to acquire these treasures and Mary frequently had to resort to her considerable persuasive powers to fulfil her wishes. In her own words 'I frequently had to go hat-in-hand asking for money from influential people so that I could buy what I wanted!'

Possibly one of the most notable and valuable works acquired was Redoute's *Les Liliacées*. The four volumes were purchased in England for £200 and transported to South Africa in the baggage of General J.C. Smuts after he had attended the signing of the treaty of Versailles in 1919. General Smuts was a great friend of Pole Evans and a frequent visitor to the Division of Botany.



FIGURE 1. — Mary Davidson Gunn (1899–1989).

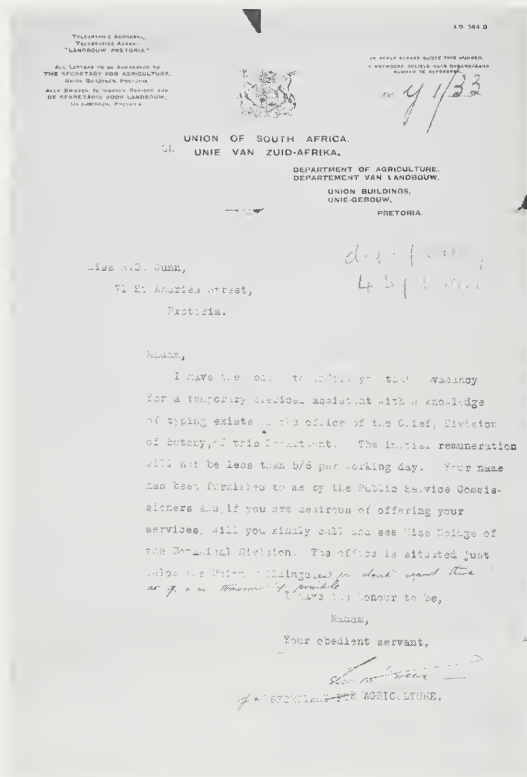


FIGURE 2.—Letter of appointment of Miss Gunn to the Division of Botany in September 1916.



FIGURE 4.—The young librarian.



FIGURE 3.—Women Staff—Botany & Plant Pathology, 1919. Back row L to R: Misses V. Bottomley, E. Tenant, K. Lansdell, A. Bottomley, Z. Findley, Dr E.M. Doidge, Miss S.M. Stent. Sitting L to R: Miss I. Verdoorn, Miss King, Mrs Stocks, Misses I. Tamblin, E. Linde, M.D. Gunn, K. Vos.

It is of interest to enumerate a few of the other, today almost priceless treasures which, through meticulous research and personal determination and endeavour, Mary Gunn was able to acquire for the library:

In G. Rondelletii ... *methodicam pharmaceuticum officinarum animadversiones* (1605) M. de l'Obel
Florilegium (1612) E. Sweet
Exoticarium plantarum (1670) J. Breyné

Horti medici amstelodamensis (1697–1701) J. Commelin
Plantae selectae (1750–1773) C.J. Trew
Geraniologia (1787–1788) C.L. L'Héritier
Icones plantarum rariorum (1781–86) and *Oxalis* (1794) N.J. Jacquin
The Botanists repository (1797–1815) H.C. Andrews (Figure 5)
Medicinal plants of the Cape (1857) C.W.L. Pappe

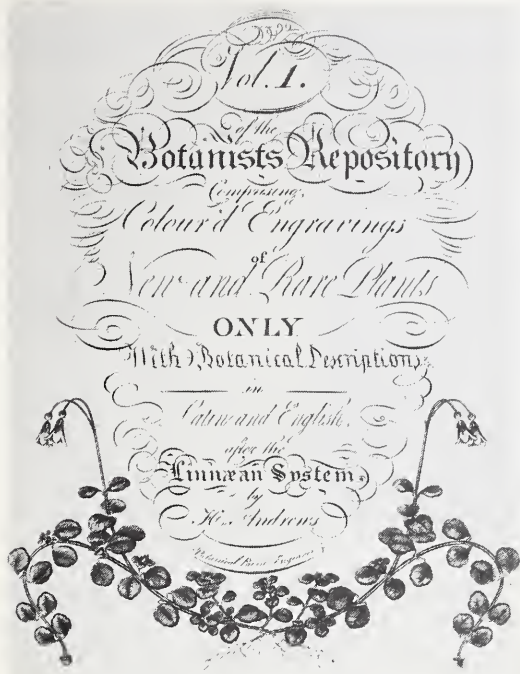


FIGURE 5.—Title page of the *Botanists Repository*, one of the priceless treasures in the Mary Gunn Library.

Genera of South African plants (1838) Harvey, generally considered to be the first scientific work published in South Africa. This book, purchased in Johannesburg for ± R9,00 is of special interest as it contains handwritten notes by the author.

Notable series acquired included a full set of *Curtis's Botanical Magazine* published from 1790 onwards and the exceptionally valuable Loddiges' *Botanical Cabinet*. These beautiful leather-bound, gold-leaf-edged volumes were

purchased personally by Mary Gunn in England before 1939 and held by the booksellers until the end of World War 2 when they could be safely delivered to Pretoria.

Dr Iltyd Pole Evans, chief of the Division of Botany from 1913 to 1939 had a profound influence on the botanical fields in which he became involved and he similarly influenced and inspired many of his staff. His continual queries about botanical explorers led Mary Gunn into her second field of specialization, namely biographical research of early botanists. Information about travellers such as Thunberg, Burchell, Masson, Ecklon and many more was diligently collected from all corners of the globe. A cherished ambition was finally realized in 1981 when the major part of all this information was used for the publication *Botanical exploration in southern Africa*. This work, produced in collaboration with her one-time chief Dr Leslie Codd, was the culmination of more than 65 years of research.

In spite of her redoubtable knowledge this was to be her only really significant personal publication. With Enid du Plessis she introduced and edited *The Flora capensis of Jakob and Johann Philipp Breynia*. This was a publication of original 17th and 18th century water-colour drawings contained in an album which is one of the Africana treasures of H.F. Oppenheimers's Brenthurst Collection.

Apart from these two works her publications were limited to tributes or notes on botanical colleagues or personalities. She had always hoped to publish an account of the adventurous Colonel Robert Gordon who was commandant of the Dutch Garrison at the Cape from 1780 until 1795 when he committed suicide after surrendering to the British. The history of this colourful soldier and naturalist was particularly dear to her heart. When she realized, in her eighties, that she would never be able to utilize her information it was passed on to other historians. This assistance was acknowledged by Raper and Boucher in their two volumes on Gordon which were published in 1988. Her generosity in passing on the results of a



FIGURE 6.—Official opening of the Mary Gunn Library, 15th January 1970. From left to right: Dr B. de Winter, Deputy Director, Botanical Research Institute; Dr J.W. Geyer, Chief Director of Research, Department of Agriculture; Miss M.D. Gunn and Dr L.E. Codd, Director, B.R.I.



FIGURE 7.—View of the Mary Gunn Library.

lifetime of research was one of the most noteworthy attributes of this remarkable woman. Numerous publications such as *Aloes of South Africa* (Reynolds), *Trees of southern Africa* (Palmer) and *There was a man* (Gutsche) bear witness to this quality.

In dedicating Volume 32 of *The Flowering Plants of Africa* series to Mary Gunn in 1957/58, editor Dr Leslie Codd writes: Librarian, authority on Africana, who during her 40 years of service in the Department of Agriculture, has with unremitting devotion built up a comprehensive botanical library in the Division of Botany, who has assisted so many research workers in tracing literature relevant to their problems and who has since its inception fostered the best interests of '*The Flowering Plants of Africa*'.

After retiring officially in 1954 she continued working in a temporary capacity until 1973 but until a few years before her death she still enjoyed spending a few hours a week in the privacy of her office. Here she would peruse her personal collection of books and be available to readily offer advice or search for information for anyone who needed her expertise.

In 1976 she was honoured with the award of The Bolus Medal which recognizes outstanding achievement in the field of botany by those without formal training in this field of science. But her highest honour was undoubtedly the dedication of the Mary Gunn Library in 1969 (Figure 6). It was a fitting tribute and now stands as a memorial to someone who virtually single-handedly built up the library (Figure 7) and served it with devotion and distinction for almost 60 years.

Mary Gunn possessed charm, coupled with a sharp, sometimes caustic wit, a sense of humour, steely determination and a high regard for those she felt warranted respect. These qualities were admired by many who knew her personally or who had corresponded with her. Although quite happy to live alone she enjoyed good company and was a loyal and loving friend to those dear to her.

Tributes to Mary's colleagues Inez and Cythna closed with quotations from the latter's book of poems *Children of the hours*. No suitable quotation from that work could be found to close this tribute to the last of the Three Graces, but what could be more apt than fellow Scot Thomas Carlyle's words:

'All that mankind has done, thought, gained or been: it is lying as in magic preservation in the pages of books. They are the chosen possession of men.'

PUBLICATIONS OF M.D. GUNN

- GUNN, M.D. 1940. Joseph Burtt Davy. *Journal of the South African Forestry Association* 5: 10.
- 1951. A.E. Roupell. *Africana Notes and News* 8: 55.
 - 1967. E.M. Doidge. *Bothalia* 9: 251–253.
 - 1969. E.P. Phillips. *Bothalia* 10: 1–3.
 - 1970a. J.W. Bews. *Standard Encyclopaedia of South Africa* 2: 301.
 - 1970b. Joseph Burtt Davy. *Standard Encyclopaedia of South Africa* 2: 605.
 - 1971a. A. Dieterlen. *Standard Encyclopaedia of South Africa* 4: 38.
 - 1971b. M.K. Dinter. *Standard Encyclopaedia of South Africa* 4: 41–42.
 - 1971c. I.B. Pole Evans. *Bothalia* 10: 131–135.
 - 1972. M.G.A. Henrici. *Bothalia* 10: 503–508.
 - 1973. J. Hutchinson. *Bothalia* 11: 1–3.
- CODD, L.E. & GUNN, M.D. 1979. Plant collecting pioneers in the Barberton area. *Veld & Flora* 65: 98–101.
- 1982a. More early references to Cape plants. *Veld & Flora* 68: 93–94.
 - 1982b. The collecting activities of Anton Rehmann (1840–1917) in South Africa. *Bothalia* 14: 1–14.
 - 1983. More notes on plant collectors. *Veld & Flora* 69: 145–147.
 - 1984a. J.D.C. Lamb and the 'Herbarium Lambii'. *Veld & Flora* 70: 62–63.
 - 1984b. Some more notes on plant collectors. *Veld & Flora* 70: 67–68.
 - 1985a. Additional biographical notes on plant collectors in southern Africa. *Bothalia* 15: 631–654.
 - 1985b. More early illustrations of Cape plants. *Veld & Flora* 71: 86–88.
- GUNN, M.D. & CODD, L.E. 1984. *Botanical exploration of southern Africa*. Balkema, Claremont, Cape.
- GUNN, M.D. & DU PLESSIS, E. 1978. *The Flora capensis of Jakob and Johann Philipp Breyne*. Brenthurst Press, Johannesburg.
- LETTY, C.L. & GUNN, M.D. 1975. E.G. Rice. *The Transvaal Gardener* 45: 65.

Book Reviews

FIELD GUIDE TO THE WILD FLOWERS OF THE WITWATERS-RAND AND PRETORIA REGION, by BRAAM VAN WYK and SASA MALAN. 1988. *Struik Publishers*, Oswald Pirow St, Foreshore, Cape Town 8001. ISBN 0 86977 814 5. Pp. 352 with full-colour photographs arranged in more than 130 plates and line drawings by Anne Pienaar. Size 210 × 147 × 27 mm. Price: soft cover ± R35,00 + GST.

This invaluable book is undoubtedly one of the most ambitious and useful plant identification guides ever published in southern Africa. It covers 763 species, almost half the total number present in the Highveld region of the southern Transvaal.

The problem of identifying wild flowers in a floristically rich area is solved in a refreshingly new and practical way. Species are arranged in six colour groups, so that the flower colour is used as the first clue to identity. Some species with variable flower colours are included in more than one colour group. Concise descriptions and line drawings of leaves are provided. Grasses (so often ignored in general field guides) are treated in a separate chapter. Useful hints on the identification of this difficult family are supplemented by line drawings which give the more salient features of the 74 species presented. The arrangement of photographs and clever layout (descriptions are consistently given directly opposite each illustration) make the book very easy to use. Since the shape and venation of leaves are not always visible in the full-colour plates, line drawings are provided. The photographs are generally of an excellent quality, even those featuring very unphotogenic subjects! By including several obscure and rather inconspicuous species (I am referring particularly to the inclusion of green and even brown 'flowers') the authors have greatly enhanced the value of the book.

The detailed text is written in an easy-to-read style and technical terms are carefully explained to the layman. Useful general information is given in the introductory chapter, describing the principles of classification and identification, as well as the flora and vegetation of the field guide area. This is followed by guidelines on how to use the book, after which the most important families are briefly described. I agree with the authors that the recognition of families is the first step towards competence in plant identification, despite the initial difficulties for a person without any botanical training. The family descriptions and the useful glossary in the back of the book should go a long way towards solving this problem. The authors have, in my opinion, provided all the necessary information for a teach-yourself course in general botany.

Technically, the book is well designed and presented. Hirt & Carter have done a commendable job on the reproduction of plates and the colours (even the blues and purples) are as true as one can reasonably expect. The text is remarkably free of errors. I did however, wonder about the spelling of *Kohautia* (Rubiaceae), which is given as *Kohautia* in all standard references. The binding of one of my copies has started to deteriorate, but this may well be due to rough handling.

Apart from being an excellent identification guide, the book also contains a wealth of general botanical information for the layman. I am sure that it will contribute to a greater appreciation for a flora which is suffering from the impact of a human population exceeding five million. I strongly recommend this book to anyone who has become aware that, to quote from the preface: 'there is more to the Highveld vegetation than grass, maize, cosmos, wattles and gum trees'. Indeed, no-one in this part of the world should be without a copy.

B-E. VAN WYK*

* Department of Botany, Rand Afrikaans University, P.O. Box 524, Johannesburg 2000.

THE HERBARIUM HANDBOOK, by L. FORMAN and D. BRIDSON 1989. *Royal Botanic Gardens, Kew*, Richmond, Surrey, TW9 3AB, England. Pp. 214, 93 references, 52 figures. Size 245 × 155 × 15 mm. Price: £12.

This publication was compiled from the lecture notes of various authors who have contributed to the *International diploma course in herbarium*

techniques held annually at Kew since 1987. The handbook deals mainly with the technical aspects of herbarium work including the preparation, housing, preservation and organization of herbarium collections and related subjects.

It comprises thirty-nine chapters divided into five sections. These include an introduction which addresses the question 'What is taxonomy?' and then covers the development, purpose and types of herbaria. Other sections cover the herbarium building, collections and materials; herbarium techniques and management; additional techniques, for example photography, the use of maps, gazetteers and computers; plant collecting and finally three chapters on the role of the herbarium in supporting economic botany, ecology and conservation.

The publication, appropriately depicting on its cover the wooden latticework and straps of a plant press, is undoubtedly the best of its kind to date. It combines the collective, internationally gained expertise of no less than twenty-four herbarium botanists from Kew and draws on a wealth of knowledge from the 103 references cited. Previous publications have not succeeded to quite the same extent in addressing the full spectrum of herbarium functions. Aspects included in the handbook which have received little or no coverage in comparable works include the dissection of floral organs and the preservation of the results; the use of photography in fieldwork; the photographic copying of herbarium sheets; the preparation of checklists of geographical regions; collecting for seedbanks; collecting living material; guidelines for dealing with visitors to the herbarium and, to a lesser extent, the re-arrangement of herbarium collections according to new publications. The book also includes a list of seventy-three families together with the plant parts essential for their identification; and a comprehensive list of how to handle herbarium specimens in order to ensure minimum damage, and specialist collecting techniques for pteridophytes, bryophytes, fungi and lichens.

This publication achieves what it sets out to be (a good all-purpose handbook for herbarium curators) by fulfilling the following criteria: it is simultaneously concise and explicit, discussing in practical terms the pros and cons of a range of herbarium techniques in a manner that makes for easy application by even the most inexperienced of herbarium workers; recommendations and cautions are offered where appropriate; references for additional reading are provided at the end of each chapter; finally, the superior quality of the paper and binding are in keeping with a book that will have to stand up to constant use. One does, however, suspect that the index is not as comprehensive as could be expected. When searching for information on paper acidity, for example, no reference to this could be found in the index, even though the subject is dealt with in the text.

Despite the many strengths of this work, there is one obvious shortcoming, namely the chapter on computers. Although offered as an introduction to the use of computers in herbaria, this area is receiving much attention worldwide and should have been dealt with in more detail, particularly the aspect of computerized herbarium databases.

In conclusion, one must congratulate the editors on an outstanding reference work through which the staff at the Royal Botanic Gardens, Kew, endeavour to share their knowledge and expertise gathered during years of involvement with herbarium curation and management. Although the book concentrates largely on the procedures followed at the Kew Herbarium in a European context, these are essentially capable of universal application with little or no modification. Viewed from a southern African context, this book will certainly play an important role in bringing to curators of the region those essential techniques which are barely touched upon in university and technician curricula and which, except in the few larger herbaria, are not passed on to apprentice curators. One can therefore look forward to a general improvement in the standard of curation in these herbaria. It is predicted that this handbook will become the standard source of reference for curators for many years to come.

T.H. ARNOLD

THE GENUS *WATSONIA*, Annals of Kirstenbosch Botanic Gardens Volume 19, by PETER GOLDBLATT and various artists. 1989. *National Botanic Gardens*, Private Bag X7, Claremont, 7735. Pp. 148, 27 water-colour plates and 44 black-and-white figures, 52 distribution maps. ISBN 0 620 12517 9, ISSN 0 258-3305. Price: R50,00 + GST.

This monographic account of the southern African endemic genus *Watsonia* Mill., is the second major revision by Goldblatt to be published in the *Annals of Kirstenbosch Botanic Gardens*. The first, Volume 14, *The Moraea of southern Africa*, 1986, was reviewed in *Bothalia* 17,2: 298 (1987).

As in the *Moraea* revision, a double-columned text layout is used, and there are numerous watercolour and black-and-white illustrations. The watercolour painting of one of the included species, *W. dubia* Eckl. ex Klatt, is repeated on the dust jacket. The chapter headings and contents are essentially similar to those of the previous work.

Some pleasing improvements were noted: space-saving (and cost-saving) has been achieved by placing the colour plates in groups of eight, at intervals throughout the volume. In the systematics section, the text for each taxon therefore usually follows directly upon that for the previous taxon. The plates and figures for each are of necessity now numbered, and referenced in the text. The figures are also now captioned. The volume's smaller A4 size format allows for easier handling. The taxonomic index has been rendered easier to use by listing the genus name in full for each entry.

Sadly, as in the *Moraea* revision, some minor errors have crept in, such as incorrect or transposed collectors' numbers, and incorrectly cited grid references, as on pp. 23, 104, 114, 116. However, these are only likely to be noticed by herbarium workers and do not detract at all from the value of this publication.

A more serious error is the omission of the Latin diagnosis from the text for the new species, *W. confusa* Goldbl., rendering it invalidly published.

The contents can be divided into two parts, the first of which includes an introductory chapter, with Table 1 listing the two subgenera, three sections, three subsections and 52 species recognised, plus a brief distribution and general habitat description for each. Then there is a history of the genus from Linnaean to present times, followed by a chapter discussing important morphological characters and cytology, accompanied by Table 2 listing chromosome counts for the 31 taxa studied to date.

A discussion of generic relationships and phylogeny follows. *Watsonia*, together with four other small genera, is placed within its own tribe, Watsonieae, and is separated from its two sister tribes within the subfamily Ixiodeae, Ixieae and Pillansieae, by, *inter alia*, the corm being of axillary rather than apical origin, and the deeply divided style branches. Relationships within the Watsonieae are discussed and presented in the form of a cladogram, and the major species groups recognised within *Watsonia* are treated in a similar fashion. The subgeneric classification presented here is new, being based on a large body of evidence not readily available to earlier workers.

The following chapter, on ecology and geography, includes sections on climate, soils and habitat, on fire phenology, on pollination biology, on geography and on centres of diversity. It is interesting that variations in floral structure and colour can be directly correlated to different pollinators, as has been borne out by observations by the author and others in the field. Thus the long-tubed red-flowered species are generally bird-pollinated, and the short-tubed pink-flowered species are generally bee-pollinated.

As in *Moraea*, *Watsonia* occurs in both the winter and summer rainfall areas of southern Africa, with the northernmost record being from Woodbush near Pietersburg. In the winter rainfall area the highest concentration occurs in the south-western Cape, with no less than 16 species in the Worcester quarter degree square. There is a secondary centre of diversity in the southern Cape, with 11 species recorded in the Oudtshoorn grid. In the summer rainfall area a centre of high diversity is found in the Lydenburg and Pilgrim's Rest grids, and a second one in the Port Edward and Port St. Johns grids. Interestingly, a viviparous

cultivar of *W. meriana* (L.) Mill. has become naturalised on Mauritius and Réunion and in Australia.

The final chapter in this part has comprehensive notes on cultivation. The horticultural value of the genus has long been recognized, as many of the species are spectacular in massed display, and more importantly are easy to grow, provided that their requirements regarding watering (this depends on the particular rainfall area to which they are native) and frequent lifting and division of the corms, are met.

The second and major part of this volume is devoted to a systematic treatment, with a description of the genus, a key to the species (which works!) and then an enumeration, references, synonymy, description and discussion of each taxon, with distribution maps, specimen citation and black-and-white illustrations. Finally there is a discussion of hybrids, doubtful or unknown species, and excluded species, plus an extensive bibliography and a taxonomic index to the species.

Turning now to a discussion of the plates and figures: twenty-seven watercolour plates are included, of which 14 have appeared in early volumes of *The Flowering Plants of Africa*. Except for plate 10, *Watsonia pulchra*, originally published as *Watsonia densiflora* in *The Flowering Plants of Africa* t. 1293, it is the first time that these original paintings have been reproduced. (The reason for this is that up until Volume 24, *The Flowering Plants of Africa* was printed in England. These early plates were reproduced in black-and-white by the lithographic process, then sent to competent hand-colour artists. Mainly due to the scarcity of these artists, especially during the 1939–45 war, it was decided in 1944 to change over entirely to colour printing.)

It is difficult to make constructive comment about the colour reproduction on the early plates, as most are housed in Bolus Herbarium, Cape Town, and therefore a comparison to the originals cannot be made. However, the pencil habit and dissection drawings have been printed far too dark, making them appear very crude. They distract and spoil otherwise very attractive plates (note also, style drawings on Fay Anderson's plates).

The seven illustrations commissioned from Fay Anderson and one from John Manning have been beautifully executed and are refreshingly crisp. Unfortunately, in a number of them the colour printing is poor, leaving them very washed out (compare the cover illustration of *W. dubia* with that of plate 6). This problem which is also encountered in the *Moraea* revision, could have easily been avoided by better supervision of colour proofing and printing.

Unfortunately the illustration facing the title page is unsigned and the artist is not acknowledged.

The text figures are very disappointing. They are generally poorly arranged, and do not employ the allocated space to best advantage, e.g. figures 10 and 20. The use of small areas of solid shading is, if anything, distracting, and serves no scientific or artistic purpose. The corms of *Watsonia* provide important diagnostic characters (especially useful to the horticulturist and herbarium worker), yet in the majority of figures they have been omitted.

It is a pity that greater effort was not made to select more plates of high quality, and that more originals were not commissioned.

There are a couple of minor errors in the acknowledgements: e.g. Cythna Letty — not Cynthia — and seven of the plates — not six — are by Fay Anderson, and one is by John Manning.

A pleasing touch for the benefit of the non-botanist is the brief explanation of the specific name for each species.

In conclusion, *Watsonia* has long been a troublesome genus for the herbarium worker and the present publication will surely solve many of the problems experienced. It will also prove valuable to the horticulturist and interested non-botanist.

C. REID and G. CONDY

Guide for authors to *Bothalia*

This guide is updated when necessary and includes an index. The latest version should therefore be consulted.

Bothalia is named in honour of General Louis Botha, first Premier and Minister of Agriculture of the Union of South Africa. This house journal of the National Botanical Institute, Pretoria, is devoted to the furtherance of botanical science. The main fields covered are taxonomy, ecology, anatomy and cytology. Two parts of the journal and an index to contents, authors and subjects are published annually.

1 Editorial policy

Bothalia welcomes original papers dealing with flora and vegetation of southern Africa and related subjects. Full-length papers and short notes, as well as book reviews, are accepted. Manuscripts may be written in either English or Afrikaans.

Articles are assessed by referees, both local and overseas. Authors are welcome to suggest possible referees to judge their work. Authors are responsible for the factual correctness of their contributions. *Bothalia* maintains an editorial board (see title page) to ensure that international standards are upheld.

Articles should preferably be submitted on PC diskettes or stiffies but the format of all articles should conform to paragraphs 3.2 to 3.5. Articles not submitted in electronic form should be arranged according to section 3.

2 Requirements for a diskette

- 2.1 data must be IBM compatible and written in ASCII.
- 2.2 a printout of the diskette should be supplied to indicate (in pencil) the necessary underlining, paragraphs etc.
- 2.3 tables need not be placed on the diskette—a typed version is adequate.
- 2.4 the diskette must have single line spacing, the printout with markings must be in double line spacing.
- 2.5 do not justify lines.
- 2.6 do not break words, except hyphenated words.
- 2.7 all lines, headings, keys, etc., should start flush at the margin, therefore no indentations of any kind.
- 2.8 no italics, bold or underlined words.
- 2.9 paragraphs and headings are delineated by an extra line spacing (carriage return) and no indentation.
- 2.10 a hyphen is designated as one dash, with no space between the letter and the dash, e.g. ovate-lanceolate. See also 17.6.
- 2.11 an N-dash is typed as two hyphens with no space between the letter and the hyphen, e.g. 2--5 mm (typeset, it looks like this, 2–5 mm).
- 2.12 an M-dash is typed as three hyphens with no space between the letter and the hyphen, e.g. computers---what a blessing! (typeset, it looks like this, computers—what).

2.13 do not use a double space between words, after commas, full stops, colons, semicolons or exclamation marks.

2.14 use lower case x as a times sign, with one space on either side of the x, e.g. 2 x 3 mm.

2.15 use single (not double) opening and closing quotes.

2.16 keys—put only three leader dots before number and name of taxon (with a space before and a space after the first and last dot), regardless of how far or near the word is from the right margin, e.g. ... 1. *R. ovata*.

3 Requirements for a manuscript

3.1 Manuscripts should be typewritten on one side of good quality A4-size paper, double-spaced throughout (including abstract, tables, captions to figures, literature references, etc.) and have a margin of at least 30 mm all round. The original and three photocopies (preferably **photocopied on both sides** of the paper to reduce weight for postage) of all items, including text, illustrations, tables and lists should be submitted, and the author should retain a complete set of copies.

3.2 Papers should conform to the general style and layout of recent issues of *Bothalia* (from volume 17 onwards).

3.3 Material should be presented in the following sequence: Title page with title, name(s) of author(s), keywords, abstracts (in English and Afrikaans) and information that should be placed in a footnote on the title page, such as address(es) of author(s) and mention of granting agencies.

3.4 The sequence continues with Introduction and aims, Material and methods, Results, Interpretation (Discussion), Acknowledgements, Specimens examined (in revisions and monographs), References, Index of names (recommended for revisions dealing with more than about 15 species), Tables, Captions for figures and figures. In the case of short notes and book reviews, keywords and abstract are superfluous.

3.5 All pages must be numbered consecutively beginning with the title page to those with references, tables and captions to figures.

3.6 For notes on the use of hyphens and dashes see 2.10 to 2.12.

4 Author(s)

When there are several authors the covering letter should indicate clearly which of them is responsible for correspondence and, if possible, telephonically available while the article is being processed. The contact address and telephone number should be mentioned if they differ from those given on the letterhead.

5 Title

The title should be as concise and as informative as possible. In articles dealing with taxonomy or closely

related subjects the family of the taxon under discussion (see also 13.2) should be mentioned in brackets but author citations should be omitted from plant names.

6 Keywords

Up to 10 keywords (or index terms) should be provided in English in alphabetical sequence. The following points should be borne in mind when selecting keywords:

6.1 Keywords should be unambiguous, internationally acceptable words and not recently-coined little-known words.

6.2 they should be in a noun form and verbs should be avoided.

6.3 they should not consist of an adjective alone; adjectives should be combined with nouns.

6.4 they should not contain prepositions.

6.5 the singular form should be used for processes and properties, e.g. evaporation.

6.6 the plural form should be used for physical objects, e.g. augers.

6.7 location (province and/or country); taxa (species, genus, family) and vegetation type (community, veld type, biome) should be used as keywords.

6.8 keywords should be selected hierarchically where possible, e.g. both family and species should be included.

6.9 they should include terms used in the title.

6.10 they should answer the following questions:

6.10.1 what is the *active concept* in the document (activity, operation or process).

6.10.2, what is the *passive concept* or object of the active process (item on which the activity, operation or process takes place).

6.10.3, what is the means of accomplishment or how is the active concept achieved (technique, method, apparatus, operation or process).

6.10.4 what is the environment in which the active concept takes place (medium, location).

6.10.5 what are the independent (controlled) and dependent variables?

6.11 questions 6.10.1 to 6.10.3 should preferably also be answered in the title.

7 Abstract

7.1 Abstracts of no more than 200 words should be provided in English and Afrikaans. Abstracts are of great importance and should convey the essence of the article.

7.2 They should refer to the geographical area concerned and, in taxonomic articles, mention the number of taxa treated. They should not contain information not appearing in the article.

7.3 In articles dealing with taxonomy or closely related subjects all taxa from the rank of genus downwards should be accompanied by their author citations.

7.4 Names of new taxa and new combinations should not be underlined. If the article deals with too many taxa only the important ones should be mentioned.

8 Table of contents

A table of contents should be given for all articles longer than about six typed pages, unless they follow the strict format of a taxonomic revision.

9 Acknowledgements

Acknowledgements should be kept to the minimum compatible with the requirements of courtesy. Please give all the initials of the person(s) you are thanking.

10 Literature references

10.1 Literature references in the text should be cited as follows: 'Jones & Smith (1986) stated...', or '...(Jones & Smith 1986)' or (Ellis 1988: 67) when giving a reference simply as authority for a statement. For treatment of literature references in taxonomic papers see 14.

10.2 When more than two authors are involved in the paper use the name of the first author followed by *et al.*

10.3 When referring to more than one literature reference, they should be arranged alphabetically according to author and separated by a semicolon, e.g. (Anon. 1981, 1984; Davis 1976; Nixon 1940).

10.4 Titles of books and names of journals should preferably not be mentioned in the text. If there is good reason for doing so, they should be treated as described in 10.17.

10.5 Personal communications are given only in the text, not in the list of references. Please add the person's full initials to identify the person more positively, e.g. C. Boucher pers. comm.

10.6 References of the same author are arranged in chronological sequence.

10.7 Where two or more references by the same author are listed in succession, the author's name is repeated with every reference.

10.8 All publications referred to in the text, including those mentioned in full in the treatment of correct names in taxonomic papers, but no others, and no personal communications, are listed at the end of the manuscript under the heading References.

10.9 The references are arranged alphabetically according to authors and chronologically under each author, with a, b, c, etc. added to the year, if the author has published more than one work in a year.

10.10 If an author has published both on his own and as a senior author with others, the solo publications are listed first and after that, in strict alphabetical sequence, those published with one or more other authors.

10.11 Author names are typed in capitals.

10.12 Titles of journals and of books are written out in full and are underlined as follows: *Transactions of the Linnean Society of London* 5: 171–217, or *Biology and ecology of weeds*: 24.

10.13 Titles of books should be given as in *Taxonomic literature*, edn 2 by Stafleu & Cowan and names of journals as in the latest edition of *World list of scientific periodicals*.

10.14 If the same author is mentioned more than once, the name is written out in full and not replaced by a line.

10.15 Examples of references:

Collective book or Flora

- BROWN, N.E. 1909. Asclepiadaceae. In W.T. Thiselton-Dyer, *Flora capensis* 6,2: 518–1036. Reeve, London.
BROWN, N.E. 1915. Asclepiadaceae. In W.T. Thiselton-Dyer, *Flora of tropical Africa* 5,2: 500–600. Reeve, London.

Book

- DU TOIT, A.L. 1966. *Geology of South Africa*, 3rd edn, S.M. Haughton (ed.). Oliver & Boyd, London.
HUTCHINSON, J. 1946. *A botanist in southern Africa*. Gawthorn, London.

Journal

- DAVIS, G. 1988. Description of a proteoid-restioid stand in Mesic Mountain Fynbos of the south-western Cape and some aspects of its ecology. *Bothalia* 18: 279–287.
STEBBINS, G.L. Jr 1952. Aridity as a stimulus to plant evolution. *American Naturalist* 86: 35–44.
SMOOK, L. & GIBBS RUSSELL, G.E. 1985. Poaceae. *Memoirs of the Botanical Survey of South Africa* No. 51: 45–70.

In press, in preparation

- TAYLOR, H.C. in press. *A reconnaissance of the vegetation of Rooiberg State Forest*. Department of Forestry, Technical Bulletin.
VOGEL, J.C. 1982. The age of the the Kuiseb river silt terrace at Homeb. *Palaeoecology of Africa* 15. In press.
WEISSER, P.J., GARLAND, J.F. & DREWS, B.K. in prep. Dune advancement 1937–1977 and preliminary vegetation succession chronology at Mlalazi Nature Reserve, Natal, South Africa. *Bothalia*.

Thesis

- KRUGER, F.J. 1974. *The physiography and plant communities of the Jakkalsrivier Catchment*. M.Sc. (Forestry) thesis, University of Stellenbosch.

Miscellaneous paper, report, unpublished article, technical note, congress proceedings

- ANON. no date. *Eetbare plante van die Wolkberg*. Botanical Research Unit, Grahamstown. Unpublished.
BAWDEN, M.G. & CARROL, D.M. 1968. *The land resources of Lesotho*. Land Resources Study No. 3, Land Resources Division, Directorate of Overseas Surveys, Tolworth.
BOUCHER, C. 1981. Contributions of the Botanical Research Institute. In A.E.F. Heydorn, *Proceedings of workshop research in Cape estuaries*: 105–107. National Research Institute for Oceanology, CSIR, Stellenbosch.
NATIONAL BUILDING RESEARCH INSTITUTE 1959. *Report of the committee on the protection of building timbers in South Africa against termites, woodboring beetles and fungi*, 2nd edn, CSIR Research Report No. 169.

11 Tables

11.1 Each table should be presented on a separate sheet and be assigned an Arabic numeral, i.e. the first table mentioned in the text is marked 'Table 1'.

11.2 In the captions of tables the word 'table' is written in capital letters. See recent numbers of *Bothalia* for the format required.

11.3 Avoid vertical lines, if at all possible. Tables can often be reduced in width by interchanging primary horizontal and vertical heads.

12 Figures

12.1 Figures should be planned to fit, after reduction, into a width of either 80, 118 or 165 mm, with a maximum vertical length of 230 mm. Allow space for the caption in the case of figures that will occupy a whole page.

12.2 Line drawings, including graphs and diagrams, should be in jet-black Indian ink, preferably on fine Felix Schoeller parole or similar board, 200 gsm, or tracing film. Lines should be bold enough to stand reduction.

12.3 It is recommended that drawings should be twice the size of the final reproduction.

12.4 Photographs should be of excellent quality on glossy paper with clear detail and moderate contrast, and they should be the same size as required in the journal.

12.5 Photograph mosaics should be submitted complete, the component photographs mounted neatly on a white flexible card base leaving a narrow gap of uniform width (2 mm) between each print. Note that grouping photographs of markedly divergent contrast results in poor reproductions.

12.6 Lettering and numbering on all figures should be done in letaset, stencilling or a comparable method. If symbols are to be placed on a dark background it is recommended that black symbols are used on a small white disk ± 7 mm in diameter and placed in the lower left hand corner of the relevant photo.

12.7 If several illustrations are treated as components of a single composite figure they should be designated by capital letters.

12.8 Note that the word 'figure' should be written out in full, both in the text and the captions.

12.9 In the text the figure reference is then written as in the following example: 'The stamens (Figure 4A, B, C) are...'

12.10 In captions, 'figure' is written in capital letters. Magnification of figures should be given for the size as submitted.

12.11 It is recommended that scale bars or lines be used on figures.

12.12 In figures accompanying taxonomic papers, voucher specimens should be given in the relevant caption.

12.13 Figures are numbered consecutively with Arabic numerals in the order they are referred to in the text. These numbers, as well as the author's name and an indication of the top of the figure, must be written in soft pencil on the back of all figures.

12.14 Captions of figures must not be pasted under the photograph or drawing.

12.15 Authors should indicate in pencil in the text where they would like the figures to appear.

12.16 Authors wishing to have the originals of figures returned must inform the editor in the original covering letter and must mark each original 'To be returned to author'.

12.17 Authors wishing to use illustrations already published must obtain written permission before submitting the manuscript and inform the editor of this fact.

12.18 Captions for figures should be collected together and typed on a separate sheet headed *Captions for figures*.

12.19 It is strongly recommended that taxonomic articles include dot maps as figures to show the distribution of taxa. The dots used must be large enough to stand reduction to 80 mm (recommended size: leterset 5 mm diameter).

12.20 Blank maps are available from the editor.

13 Text

13.1 As a rule authors should use the names as listed by Gibbs Russell *et al.* in *Memoirs of the Botanical Survey of South Africa* Nos 48, 51 and 56.

13.2 Names of genera and infrageneric taxa are usually underlined, with the author citation (where relevant) not underlined. Exceptions include names of new taxa in the abstracts, correct names given in the synopsis or in paragraphs on species excluded from a given supraspecific group in taxonomic articles, in checklists and in indices, where the position is reversed, correct names not being underlined and synonyms underlined.

13.3 Names above generic level are not underlined.

13.4 In articles dealing with taxonomy and closely related subjects the complete scientific name of a plant (with author citation) should be given at the first mention in the text. The generic name should be abbreviated to the initial thereafter, except where intervening references to other genera with the same initial could cause confusion.

13.5 In normal text, Latin words are italicized, but in the synopsis of a species, Latin words such as *nom. nud.* are not italicized.

13.6 Names of authors of plant names should agree with the list compiled by the BRI (TN TAX 2/1) which has also been implemented by Gibbs Russell *et al.* in *Memoirs of the Botanical Survey of South Africa* Nos 48, 51 and 56.

13.7 Modern authors not included in the list should use their full name and initials when publishing new plant names. Other author names not in the list should be in agreement with the recommendations of the Code.

13.8 Names of authors of publications are written out in full except in the synonymy in taxonomic articles where they are treated like names of authors of plant names.

13.9 Names of plant collectors are underlined whenever they are linked to the number of a specimen. The collection number is also underlined, e.g. *Acocks 14407*.

13.10 Surnames beginning with 'De', 'Du' or 'Van' begin with a capital letter unless preceded by an initial.

13.11 For measurements use only units of the International System of Units (SI). Cm should not be used, only mm and/or m.

13.12 The use of '±' is preferred to c. or ca.

13.13 Numbers 'one' to 'nine' are spelled out in normal text, and from 10 onwards they are written in Arabic numerals.

13.14 In descriptions of plants, numerals are used throughout. Write 2,0–4,5 (not 2–4,5). When counting members write 2 or 3 (not 2–3) but 2–4.

13.15 Abbreviations should be used sparingly but consistently. No full stops are placed after abbreviations ending with the last letter of the full word (e.g. edition = edn; editor = ed.), after units of measure, after compass directions and after herbarium designations.

13.16 Apart from multi-access keys, indented keys should be used with couplets numbered 1a–1b, 2a–2b, etc. (without full stops thereafter).

13.17 Keys consisting of a single couplet have no numbering.

13.18 Manuscripts of keys should be presented as in the following example:

1a Leaves closely arranged on an elongated stem; a submerged aquatic with only the capitula exserted ... 1b. *E. setaceum* var. *pumilum*

1b Leaves in basal rosettes; stems suppressed; small marsh plants, ruderals or rarely aquatics:

2a Annuals, small, fast-growing pioneers, dying when the habitat dries up; capitula without coarse white setae; receptacles cylindrical:

3a Anthers white ... 2. *E. cinereum*

3b Anthers black ... 3. *E. nigrum*

2b Perennials, more robust plants; capitula sparsely to densely covered with short setae:

13.19 Herbarium voucher specimens should be referred to wherever possible, not only in taxonomic articles.

14 Species treatment in taxonomic papers

14.1 The procedure to be followed is illustrated in the example (17, 17.8), which should be referred to, because not all steps are described in full detail.

14.2 The correct name (not underlined) is to be followed by its author citation (underlined) and the full literature reference, with the name of the publication written out in full (not underlined).

14.3 Thereafter all literature references, including those of the synonyms, should only reflect author, page and year of publication, e.g. C.E. Hubb. in *Kew Bulletin* 15: 307 (1960); Boris *et al.*: 14 (1966); Boris: 89 (1967); Sims: t. 38 (1977); Sims: 67 (1980).

14.4 The description and the discussion, which should consist of paragraphs commencing, where possible, with italicized leader words such as *flowering time*, *diagnostic characters*, *distribution* and *habitat*.

14.5 When more than one species of a given genus is dealt with in a paper, the correct name of each species should be prefixed by a sequential number followed by a full stop, the first line of the paragraph to be indented. Intraspecific taxa are marked with small letters, e.g. 1b., 12c., etc.

14.6 Names of authors are written in the same way (see 13.1, 13.6), irrespective of whether the person in question is cited as the author of a plant name or of a publication.

14.7 The word 'figure' is written as 'fig.', and 't.' is used for both 'plate' and 'tablet'.

14.8 Literature references providing good illustrations of the species in question may be cited in a paragraph commencing with the word *Icones* followed by a colon. This paragraph is given after the last paragraph of the synonymy, see 17.8.

15 Citation of specimens

15.1 Type specimen in synopsis: the following should be given (if available): country (if not in RSA), province, grid reference (at least for new taxa), locality as given by original collector, modern equivalent of collecting locality in square brackets (if relevant), date of collection (optional), collector's name and collecting number (both underlined).

15.2 The abbreviation *s.n.* (*sine numero*) is given after the name of a collector who usually assigned numbers to his collections but did not do so in the specimen in question. The herbaria in which the relevant type(s) are housed are indicated by means of the abbreviations given in the latest edition of *Index Herbariorum*.

15.3 The holotype (holo.) and its location are mentioned first, followed by a semicolon, the other herbaria are arranged alphabetically, separated by commas.

15.4 Authors should indicate by means of an exclamation mark (!) which of the types have been personally examined.

15.5 If only a photograph or microfiche was seen, write as follows: *Anon.* 422 (X, holo. —BOL, photo.!).

15.6 Lectotypes or neotypes should be chosen for correct names without a holotype. It is not necessary to lectotypify synonyms.

15.7 When a lectotype or a neotype are newly chosen this should be indicated by using the phrase 'here designated'. If reference is made to a previously selected lectotype or neotype, the name of the designating author and the literature reference should be given. In cases where no type was cited, and none has subsequently been nominated, this may be stated as 'not designated'.

15.8 In brief papers mentioning only a few species and a few cited specimens the specimens should be arranged according to the grid reference system: Provinces/countries (typed in capitals) should be cited in the following order: SWA/Namibia, Botswana, Transvaal, Orange Free State, Swaziland, Natal, Lesotho, Transkei and Cape.

15.9 Grid references should be cited in numerical sequence.

15.10 Locality records for specimens should preferably be given to within a quarter-degree square. Records from the same one-degree square are given in alphabetical order, i.e. (—AC) precedes (—AD), etc. Records from the same quarter-degree square are arranged alphabetically according to the collectors' names; the quarter-degree references must be repeated for each specimen cited.

15.11 The relevant international code of the herbaria in which a collection was seen should be given in brackets after the collection number; the codes are separated by commas. The following example will explain the procedure:

NATAL. —2731 (Louwsburg): 16 km E of Nongoma (—DD), *Pelser* 354 (BM, K, PRE); near Dwaarsand, *Van der Merwe* 4789 (BOL, M). 2829 (Harrismith): near Groothoek (—AB), *Smith* 234; Koffiefontein (—AB), *Taylor* 720 (PRE); Cathedral Peak Forest Station (—CC), *Marriot* 74 (KMG); Wilgerfontein, *Roux* 426. Grid ref. unknown: Sterkstroom, *Strydom* 12 (NBG).

15.12 For records from outside southern Africa authors should use degree squares without names, e.g.:

KENYA. —0136: Nairobi plains beyond race course, *Napier* 485.

15.13 Monographs and revisions: in the case of all major works of this nature it is assumed that the author has investigated the relevant material in all major herbaria and that he has provided the specimens seen with determinavit labels. It is assumed further that the author has submitted distribution maps for all relevant taxa and that the distribution has been described briefly in words in the text. Under the heading 'Vouchers' no more than five specimens should be cited, indicating merely the collector and the collector's number (both underlined). Specimens are alphabetically arranged according to collector's name. If more than one specimen by the same collector is cited, they are arranged numerically and separated by a semicolon. The purpose of the cited specimens is not to indicate distribution but to convey the author's concept of the taxon in question.

15.14 The herbaria in which the specimens are housed are indicated by means of the abbreviation given in the latest edition of *Index Herbariorum*. They are given between brackets, arranged alphabetically and separated by commas behind every specimen as in the following example:

Vouchers: *Fisher* 840 (NH, NU, PRE); *Flanagan* 831 (GRA, PRE); 840 (NH, PRE); *Marloth* 4926 (PRE, STE); *Scheltepe* 6161, 6163, 6405 (BOL); *Schlechter* 4451 (BM, BOL, GRA, K, PRE).

15.15 If long lists of specimens are given, they should be listed together at the end of the article under the heading *Specimens examined*. They are arranged alphabetically by the collector's name and then numerically for each collector. The species is indicated in brackets by the number that was assigned to it in the text and any infraspecific taxa by a small letter. If more than one genus is dealt with in a given article, the first species of the first genus mentioned is indicated as 1.1. This is followed by the international herbarium designation. Note that the name of the collector and the collection number are underlined:

Acocks 12497 (2.1b) BM, K, PRE; 14724 (1.13a) BOL, K, P. *Archer* 1507 (1.4) BM, G.

Burchell 2847 (2.8c) MB, K. *Burman* 2401 (3.3) MO, S. *Burt* 789 (2.6) B, KMG, STE.

16 Synonyms

16.1 In a monograph or a revision covering all of southern Africa, all synonyms based on types of southern African origin, or used in southern African literature, should be included.

16.2 Illegitimate names are designated by *nom. illeg.* after the reference, followed by *non* with the author and date, if there is an earlier homonym.

16.3 *Nomina nuda* (*nom. nud.*) and invalid names are excluded unless there is a special reason to cite them,

for example if they have been used in prominent publications.

16.4 In normal text Latin words are italicized, but in the synopsis of a species Latin words such as *nom. nud.* are not italicized.

16.5 Synonyms should be arranged chronologically into groups of nomenclatural synonyms, i.e. synonyms based on the same type, and the groups should be arranged chronologically by basionyms, except for the basionym of the correct name which is dealt with in the paragraph directly after that of the correct name.

16.6 When a generic name is repeated in a given synonymy it should be abbreviated to the initial except where intervening references to other genera with the same initial could cause confusion.

17 Description and example of species treatment

17.1 Descriptions of all taxa of higher plants should, where possible, follow the sequence: Habit; sexuality; underground parts (if relevant). *Indumentum* (if it can be easily described for the whole plant). *Stems/branches*. *Bark*. *Leaves*: arrangement, petiole absent/present, pubescence; blade: shape, size, apex, base, margin; midrib: above/below, texture, colour; petiole; stipules. *Inflorescence*: type, shape, position; bracts/bracteoles. *Flowers*: shape, sex. *Receptacle*. *Calyx*. *Corolla*. *Disc*. *Androecium*. *Gynoecium*. *Fruit*. *Seeds*. *Chromosome number*. Figure (word written out in full) number.

17.2 As a rule shape should be given before measurements.

17.3 In general, if an organ has more than one of the parts being described, use the plural, otherwise use the singular, for example, petals of a flower but blade of a leaf.

17.4 Language must be as concise as possible, using participles instead of verbs.

17.5 Dimension ranges should be cited as in the example below.

17.6 Care must be exercised in the use of dashes and hyphens: a *hyphen* is a short stroke joining two syllables of a word, e.g. ovate-lanceolate or sea-green, with no space between the letter and the stroke; an *N-dash* (*en*) is a longer stroke commonly used instead of the word 'to' between numerals, '2–5 mm long' (do not use it between words but rather use the word 'to', e.g. 'ovate to lanceolate'); it is produced by typing 2 hyphens next to each other; and an *M-dash* (*em*) is a stroke longer than an N-dash and is used variously, e.g. in front of a subspecific epithet instead of the full species name; it is produced by typing 3 hyphens next to one another.

17.7 The use of '±' is preferred to c. or ca when describing shape, measurements, dimensions, etc.

17.8 Example:

1. *Bequaertiodendron magalismontanum* (Sond.) Heine & Hemsl. in Kew Bulletin: 307 (1960); Codd: 72 (1964); Elsdon: 75 (1980). Type: Transvaal, Magaliesberg, Zeyher 1849 (S, holo. –BOL, photo!).

Chrysophyllum magalismontanum Sond.: 721 (1850); Harv.: 812 (1867); Engl.: 434 (1904); Bottmar: 34 (1919). *Zeyherella magalismontanum* (Sond.) Aubrév. & Pellegr.: 105 (1958); Justin: (1973).

Chrysophyllum argyrophyllum Hiern: 721 (1850); Engl.: 43 (1904). *Boivinella argyrophylla* (Hiern) Aubrév. & Pellegr.: 37 (1958); Justin: 98 (1973). Types: Angola, Welwitsch 4828 (BM!, lecto., here designated; PRE!); Angola, Welwitsch 4872 (BM!).

Chrysophyllum wilmsii Engl.: 4, t. 16 (1904); Masonet: 77 (1923); Woodson: 244 (1937). *Boivinella wilmsii* (Engl.) Aubrév. & Pellegr.: 39 (1958); Justin: 99 (1973). Type: Transvaal, Magoebaskloof, Wilms 1812 (B, holo.; K!, P!, lecto., designated by Aubrév. & Pellegr.: 38 (1958), PRE!, S!, W!, Z!).

Bequaertiodendron fruticosa De Wild.: 37 (1923), non Bonpland: 590 (1823); Bakker: 167 (1929); Fries: 302 (1938); Davy: 640 (1954); Breytenbach: 117 (1959); Clausen: 720 (1968); Palmer: 34 (1969). Type: Transvaal, Tzaneen Distr., Granville 3665 (K, holo.; G!, P!, PRE!, S!).

Bequaertiodendron fragrans auct. non Oldemann: Glover: 149, t. 19 (1915); Henkel: 226 (1934); Stapleton: 6 (1954).

Icones: Harv.: 812 (1867); Henkel: t. 84 (1934); Codd: 73 (1964); Palmer: 35 (1969).

Woody perennial; main branches up to 0,4 m long, erect or decumbent, grey woolly-felted, leafy. *Leaves* 3–10(–23) × 1,0–1,5(–4,0) mm, linear to oblanceolate, obtuse, base broad, half-clasping. *Heads* heterogamous, campanulate, 7–8 × 5 mm, solitary, sessile at tip of axillary shoots; involucre bracts in 5 or 6 series, inner exceeding flowers, tips subopaque, white, very acute. *Receptacle* nearly smooth. *Flowers* ± 23–30, 7–11 male, 16–21 bisexual, yellow, tipped pink. *Achenes* ± 0,75 mm long, elliptic. *Pappus* bristles very many, equalling corolla, scabridulous. *Chromosome number*: 2n = 22. Figure 23B.

18 New taxa

18.1 The name of a new taxon must be accompanied by at least a Latin diagnosis. Authors should not provide full-length Latin descriptions unless they have the required expertise in Latin at their disposal.

18.2 It is recommended that descriptions of new taxa be accompanied by a good illustration (line drawing or photograph) and a distribution map.

18.3 Example:

109. *Helichrysum jubilatatum* Hilliard, sp. nov. *H. alsinoides* DC. affinis, sed foliis ellipticis (nec spatulatis), inflorescentiis compositis a foliis non circumcinctis, floribus femineis numero quasi dimidium hermaphroditiorum aequantibus (nec capitulis homogamis vel floribus femineis 1–3 tantum) distinguitur.

Herba annua e basi ramosa; caules erecti vel decumbentes, 100–250 mm longi, tenuiter albo-lanati, remote foliati. *Folia* plerumque 8–30 × 5–15 mm, sub capitulis minor, elliptica vel oblanceolata, obtusa vel acuta, mucronata, basi semi-amplexicauli, utrinque cano-lanato-arachnoidea. *Capitula* heterogama, campanulata, 3,5–4,0 × 2,5 mm, pro parte maxima in paniculas cymosas terminales aggregata; capitula subterminalia interdum solitaria vel 2–3 ad apices ramulorum nudorum ad 30 mm longorum. *Bractae involucrales* 5-seriatae, gradatae, exteriores pellucidae, pallide stramineae, dorso lanatae, seriebus duabus interioribus subaequalibus et flores quasi aequantibus, apicibus obtusis opacis niveis vix radiantibus. *Receptaculum* fere laeve. *Flores* ± 35–41. *Achenia* 0,75 mm longa, pilis myxogenis praedita. *Pappi* setae multae, corollam aequantes, apicibus scabridis, basibus non cohaerentibus.

TYPE.—Cape, 2817 (Vioolsdrif): (–CC), Richtersveld, ± 5 miles E of Lekkersing on road to Stinkfontein, kloof in hill south of road, annual, disc whitish, 7.II.1962, *Nordenstam 1823* (S, holo.; E, NH, PRE).

19 Proofs

Only page proofs are normally sent to authors. They should be corrected in red ink and be returned to the editor as soon as possible.

20 Reprints

Authors receive 100 reprints free. If there is more than one author, this number will have to be shared between them.

21 Documents consulted

Guides to authors of the following publications were made use of in the compilation of the present guide: *Annals of the Missouri Botanic Garden*, *Botanical Journal of the Linnean Society*, *Flora of Australia*, *Smithsonian Contributions to Botany*, *South African Journal of Botany* (including instructions to authors of taxonomic papers), *South African Journal of Science*.

22 Address of editor

Manuscripts should be submitted to: The Editor, Bothalia, National Botanical Institute, Private Bag X101, Pretoria 0001.

INDEX

abbreviation, 13.4, 13.5, 13.12, 13.15, 14.7, 15.2, 15.14, 16.2, 16.3, 16.4, 16.6
 abstract (uittreksel), 3.2, 7, 13.2
 acknowledgements, 9
 address of
 authors, 3.3, 4
 editor, 22
 alphabetical, 6, 10.3, 10.9, 10.10, 15.3, 15.10, 15.13, 15.14, 15.15
 Arabic numerals, 11.1, 12.13, 13.3
 ASCII, 2.1
 author(s), 1, 3.1, 4, 10.15, 12.15
 address, 3.3, 4
 citation, 5, 7.3, 13.2, 13.4, 14.2
 first, 10.2
 names, 3.3, 10.3, 10.7, 10.9, 10.11, 10.14, 12.13, 13.7, 13.8, 14.3, 14.6, 15.7, 16.2
 names of plant names, 13.6, 13.7, 13.8
 senior, 10.10
 book reviews, 1, 3.4
 books, 10.4, 10.12, 10.13, 10.15
 Bothalia, 1, 3.2, 11.2, 22
 brief taxonomic articles, 15.8
 c., 13.2, 17.7
 ca, 13.2, 17.7
 capitals, 11.2, 12.7, 12.10, 14.2, 15.8
 captions, 3.1, 3.4, 3.5, 11.2, 12.8, 12.10, 12.12, 12.14, 12.18
 checklist, 13.2
 chromosome number, 17.1, 17.8
 chronological sequence, 10.6, 10.9, 16.5
 citation
 author, 5, 7.3, 13.2, 13.4, 14.2
 literature, 14.4
 of specimens, 15
 cm, 13.11
 collection
 date, 15.1
 number, 13.9, 15.1, 15.2, 15.11, 15.13, 15.15
 collective book, 10.15

collector, 13.9, 15.1, 15.2, 15.10, 15.13, 15.15
 colon, 2.13
 comma, 2.13
 compass directions, 13.15
 composite figure, 12.7
 congress proceedings, 10.15
 contents, 8
 correspondence, 4
 countries, 6.7, 15.8
 description and example of species treatment, 17
 diagrams, 12.2
 discussion, 3.4, 14.4
 diskette, 1, 2.4
 distribution maps, 12.19, 12.20, 15.13, 18.2
 documents consulted, 21
 dot maps, 12.19, 12.20, 15.13, 18.2
 double
 line spacing, 2.4
 space, 3.1, 2.13
 drawing paper, 12.2
 drawings, 12.2
 edition, 13.15
 editor, 13.15, 22
 editorial
 board, 1
 policy, 1
 et al., 10.2, 13.6, 14.3
 example of
 new taxa, 18.3
 species treatment, 17.8
 exclamation mark, 2.13, 15.4
 family name, 5, 6.7
 fig., 14.7
 figure(s), 12, 14.7, 17.1
 reduction of, 12.1, 12.2, 12.19
 returned, 12.16
 first author, 10.2
 flora, 1, 10.15
 footnote, 3.3
 full stop, 2.13, 13.15, 13.16, 14.5
 genera, 13.2
 generic name, 13.3, 13.4, 16.6
 geographical area, 7.2
 GIBBS RUSSELL, G.E. *et al.* List of species of southern African plants. *Memoirs of the Botanical Survey of South Africa* Nos 48, 51 & 56, 10.15, 13.1, 13.6
 granting agencies, 3.3
 graphs, 12.2
 grid reference system, 15.1, 15.8, 15.9, 15.11
 headings, 2.7, 2.9
 sequence of, 3.3, 3.4
 herbaria, 15.2, 15.3, 15.11, 15.13, 15.14
 herbarium
 code, 15.11
 designations, 13.15, 15.15
 voucher specimens, 12.12, 13.19
 holo., 15.5, 17.8, 18.3
 holotype, 15.3, 15.6
 homonym, 16.2
 hyphenated words, 2.6
 hyphen, 2.10–2.12, 17.6
 IBM compatible, 2.1
 icones, 10.2, 17.8
 illegitimate names (nom. illeg.), 16.2
 illustrations, 12.3, 12.7, 12.17, 14.8
 previously published, 12.17
Index Herbariorum, 15.2, 15.14
 index of names, 3.4
 infrageneric taxa, 13.2
 initials, 9, 10.5, 13.7
 in prep., 10.15
 in preparation, 10.15
 in press, 10.15
 International
 Code of Botanical Nomenclature, 13.7
 System of Units (SI), 13.11
 invalid names, 16.3
 italics/underlining, 7.4, 10.12, 13.2, 13.3, 13.5, 13.9, 14.2, 15.1, 15.13, 15.15
 journals, 10.4, 10.12, 10.15
 names of, 10.1, 10.13

- justify, 2.5
- keys, 2.7, 2.16, 13.16, 13.17, 13.18
- keywords, 3.3, 3.4, 6
- Latin, 13.5, 15.2, 16.2, 16.3, 16.4
 - descriptions, 18.1
- layout, 3.2
- lecto., 15.6, 15.7, 17.8
- lectotype, 15.6, 15.7, 17.8
- letraset, 12.6, 12.19
- lettering, 12.6
- line
 - drawings, 12.2, 18.2
 - spacing, 2.4, 2.9
- literature
 - citations, 14.4
 - references, 3.1, 10, 10.7
 - within synonymy, 10.7, 14.8
- localities outside southern Africa, 15.12
- locality, 15.1, 15.10
- m, 13.11
- magnification of figures, 12.3, 12.10
- manuscript
 - language, 1
 - requirements, 3
- map, distribution, dot, 12.19, 12.20, 15.13, 18.2
- M-dash, 2.12, 17.6
- mm, 13.11
- margin, 2.7, 2.16, 3.1, 17.1
- material, 3.3, 3.4
- measurements, 13.11, 17.2, 17.7
- methods, 3.4, 6.10.3
- microfiche, 15.5
- miscellaneous paper, 10.15
- monograph, 3.4, 15.13, 16.1
- name
 - collector's, 15.10
 - illegitimate, 16.2
 - invalid, 16.3
- name(s) of
 - author(s), 3.3, 10.7, 10.9, 10.11, 10.14, 13.7, 13.8, 14.6
 - of plant names (TN TAX2/1), 5, 13.1, 13.6, 14.6
 - of publications, 13.8
 - plant collectors, 13.9
 - publication, 14.2
 - taxa, 2.16, 5, 7.4, 10.8, 13.2, 13.3
- N-dash, 2.11, 17.6
- neotype, 15.6, 15.7
- new
 - combinations, 7.4
 - taxa, 7.4, 13.2, 13.7, 15.7, 18
- nom. illeg., 16.2
- nom. nud., 13.5, 16.3, 16.4
- notes, 1, 3.4, 10.15
 - technical, 10.15
- number, chromosome, 17.1, 17.8
- numbering, 13.13
 - figures, 12.6, 12.13, 17.1
 - keys, 13.16, 13.17
 - pages, 3.5, 13.4
 - taxa, 2.16, 7.2, 13.4, 14.5, 15.15
- numerals, Arabic, 11.1, 12.13, 13.3
- PC diskettes, 2
- pers. comm., 10.5
- personal communications (pers. comm.), 10.5, 10.8
- photocopies, 3.1
- photograph, 12.4, 12.14, 15.5, 18.2
 - mosaic, 12.5
- plant name, 5, 13.4, 13.6, 13.7, 13.8, 14.6
- plate (t.), 14.7
- prepositions, 6.4
- proceedings, 10.15
- proofs, 19
- provinces, 6.7, 15.1, 15.8
- publications, 10.8, 13.8, 14.3
 - name of, 14.2
 - solo, 10.10
 - year of, 10.9, 14.3
- quarter-degree squares, 15.10
- quotes, 2.15
- reduction of figures, 12.1, 12.2, 12.19
- referees, 1
- reference, 3.4, 10.6, 10.7, 10.9, 10.15
 - figure, 12.9
 - grid, 15.1, 15.8, 15.9, 15.11
 - list, 10.5, 10.8, 10.9
 - literature, 3.1, 10, 10.7
- report, 10.15
- reprints, 20
- requirements for
 - diskette, 2
 - manuscript, 3
- results, 3.4
- revision, 3.4, 8, 15.13, 16.1
- scale bar, 12.11
- semicolon, 2.13, 10.3, 15.3, 15.13
- senior author, 10.10
- sequence of headings, 3.3, 3.4
- short notes, 1, 3.4
- single line spacing, 2.4
- species treatment in taxonomic papers, 14
- specimens examined, 3.4, 15.5
- STAFLEU, F.A. & COWAN, R.S. 1976–1988. *Taxonomic literature*. Vols 1–7, 10.13
- stiffies, 1
- surnames, 13.10
- symbols, 12.6
- synopsis, 13.2, 13.5, 15.1, 16.4
- synonymy, 10.7, 13.8, 14.4, 14.8, 16.6
- t., 14.3, 14.7, 17.8
- table, 2.3, 3.1, 3.4, 3.5, 11
 - of contents, 8
- tablet (t.), 14.7
- taxa
 - name of, 2.16, 5, 7.4, 10.8, 13.2, 13.3
 - new, 7.4, 13.2, 13.7, 15.7, 18
 - numbering of, 2.16, 7.2, 13.4, 14.5, 15.15
- taxonomic
 - articles/papers, 7.2, 10.8, 12.12, 12.19, 13.2, 13.8, 14
 - revision, 8
- taxonomy, 5, 7.3, 13.4, 15.8
- technical note, 10.15
- text, 3.1, 10.1, 10.4, 10.5, 10.8, 11.1, 12.8, 12.9, 12.13, 12.15, 13, 15.13, 15.15, 16.4
- thesis, 10.15
- times sign, 2.14
- title, 3.3, 5, 6.9, 6.11
 - of books, 10.4, 10.12, 10.13, 10.15
 - of journals, 10.4, 10.12, 10.13, 10.15
 - page, 1, 3.3, 3.5
- type, 15.2, 15.4, 15.7, 16.1, 16.6, 17.8
 - here designated, 15.7, 17.8
 - not designated, 15.7
 - specimen, 15.1
- underlining/italics, 7.4, 10.12, 13.2, 13.3, 13.5, 13.9, 14.2, 15.1, 15.13, 15.15
- uittreksel (abstract), 7.1
- units of measure, 13.11, 13.15
- unpublished article, 10.15
- vouchers, 15.13, 15.14
- voucher specimens, 12.12, 13.19
- World list of scientific periodicals*, 10.13
- year of publication, 10.9, 14.3

CONTENTS—INHOUD

1. Studies in the genus <i>Lotononis</i> (Crotalariaeae, Fabaceae). 9. Four new species of the <i>L. pentaphylla</i> group, section <i>Lipozygis</i> . B-E. VAN WYK	1
2. Studies in the genus <i>Lotononis</i> (Crotalariaeae, Fabaceae). 12. Four new species of the <i>L. falcata</i> group, section <i>Leptis</i> . B-E. VAN WYK	9
3. Studies in the genus <i>Lotononis</i> (Crotalariaeae, Fabaceae). 13. Two new species and notes on the occurrence of cleistogamy in the section <i>Leptis</i> . B-E. VAN WYK	17
4. Studies in the genus <i>Riccia</i> (Marchantiales) from southern Africa. 15. <i>R. hirsuta</i> and <i>R. tomentosa</i> , sp. nov., two distinct species previously treated as one. O.H. VOLK and S.M. PEROLD	23
5. Studies in the genus <i>Riccia</i> (Marchantiales) from southern Africa. 16. <i>R. albomarginata</i> and <i>R. simii</i> , sp. nov. S.M. PEROLD	31
6. New species of <i>Erica</i> (Ericaceae) from the Cape Province. E.G.H. OLIVER	41
7. Studies in the southern African species of <i>Justicia</i> and <i>Siphonoglossa</i> (Acanthaceae): seeds. K.L. IMMELMAN	49
8. Studies in the southern African species of <i>Justicia</i> and <i>Siphonoglossa</i> (Acanthaceae): indumentum. K.L. IMMELMAN	61
9. Notes on African plants:	
Asclepiadaceae. Corona lobe variation and the generic position of <i>Asclepias macra</i> . A. NICHOLAS and D.J. GOYDER	87
Asteraceae. A new species of <i>Pterothrix</i> (Gnaphalieae) from the northern Cape. F. BRUSSE ...	67
Fabaceae. Studies in the genus <i>Lotononis</i> (Crotalariaeae). 10. <i>L. esterhuyseniana</i> , a new species from the south-western Cape. B-E. VAN WYK	70
Fabaceae. Studies in the genus <i>Lotononis</i> (Crotalariaeae). 11. A new species of the section <i>Leobordea</i> from north-western Namibia. B-E. VAN WYK	73
Fabaceae. Studies in the genus <i>Lotononis</i> (Crotalariaeae). 14. Three new species of the sections <i>Telina</i> and <i>Polylobium</i> . B-E. VAN WYK	75
Liliaceae/Asphodelaceae. The correct author citations of <i>Aloe bowiea</i> and <i>A. myriacantha</i> (Alooideae). G.F. SMITH	80
Poaceae. Two new species of <i>Stipagrostis</i> (Aristideae) from the dune-Namib Desert, Namibia. B. DE WINTER	82
10. Vegetative morphology and interfire survival strategies in the Cape Fynbos grasses. H.P. LINDER and R.P. ELLIS	91
11. The ecology of the False Bay estuarine environments, Cape, South Africa. 1. The coastal vegetation. M. O'CALLAGHAN	105
12. The ecology of the False Bay estuarine environments, Cape, South Africa. 2. Changes during the last fifty years. M. O'CALLAGHAN	113
13. Miscellaneous note:	
Notes on the distribution and habitat of <i>Aloe bowiea</i> (Liliaceae/Asphodelaceae: Alooideae)—an endangered and little known species from the eastern Cape. G.F. SMITH and A.E. VAN WYK	123
14. Obituary: Mary Davidson Gunn (1899–1989). D.M.C. FOURIE	127
15. Book reviews	131
16. Guide for authors to <i>Bothalia</i>	133

Abstracted, indexed or listed in *AGRICOLA*, *Biological Abstracts*, *Current Advances in Plant Science*, *Current Contents*, *Field Crop Abstracts*, *Forestry Abstracts*, *Herbage Abstracts*, *Excerpta Botanica*, *Revue of Plant Pathology*, *Revue of Medical and Veterinary Mycology* and *The Kew Record of Taxonomic Literature*.

ISSN 0006 8241

© and published by the National Botanic Gardens/Botanical Research Institute, Private Bag X101, Pretoria 0001, South Africa. Printed by Gutenberg Book Printers (Pty) Ltd, 141 Industrial Rd, Pretoria West 0183. Tel. (012) 386-1133/4/5/6/7/8. Obtainable from the National Botanical Institute, Private Bag X101, Pretoria 0001, South Africa.